

CONCRETE AND CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

DECEMBER 1956



VOL. LI. NO. 12

FIFTY-FIRST YEAR OF PUBLICATION

PRICE 1s. 9d.

ANNUAL SUBSCRIPTION 21s., POST FREE. \$3.90 in Canada and U.S.A.

LEADING CONTENTS

	PAGE
The Application of the Results of Tests	561
Analysis of Frames with Non-prismatic Members By E. S. E. Lyle	563
Facing a Dam by the Vacuum Process	567
Lightweight Aggregate from Pulverized-fuel Ash By W. Kinniburgh	571
Design Based on Loads Causing Failure	575
Construction of Dams in Scotland	582
Runways at Airfields	584

No. 589

ISSUED MONTHLY

Registered for
Canadian Magazine Post

BOOKS ON CONCRETE

For catalogue of "Concrete Series" books on concrete and allied subjects, send a postcard to:

CONCRETE PUBLICATIONS LTD., 14 DARTMOUTH ST., LONDON, S.W.1.



For over 60 years

this trade mark has stood for speed and
strength in reinforced concrete work.

DRAGON

(Brand)

PORTLAND CEMENT

Supplied by

THE SOUTH WALES PORTLAND CEMENT & LIME CO. LTD.
PENARTH, SOUTH WALES

Telephone: Penarth 300

Telegrams: "Cement, Penarth"



...interesting!

PROMETO MOVING FORMS

**for monolithic concrete
construction**

Premeto hydraulically controlled moving forms maximise production rates, minimise labour requirements, and reduce costs considerably. They are invaluable in the construction of multi-storey buildings, silos, water-towers, shaft-linings and other forms of concrete structure.

We have the sole rights for the manufacture and use of Premeto equipment in the United Kingdom. Enquiries are invited from Consulting Engineers, Contractors and Architects for the arrangement of sub-licence agreements for individual jobs or prescribed districts.

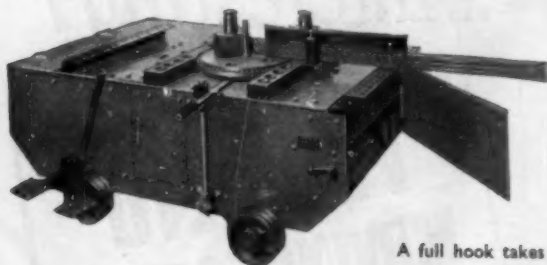
★ **A rapid and
highly economical
method of erecting
structures of all kinds.**

**WILLIAM
THORNTON
AND SONS LTD.**

WELLINGTON RD., LIVERPOOL

BUILDING AND CIVIL ENGINEERING CONTRACTORS

BAR-BENDING EQUIPMENT



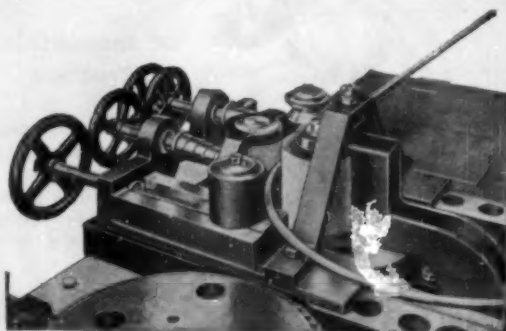
RAS.40 MODEL

This is a single-disc machine which is specially designed for an extraordinarily high rate of bending bars up to $1\frac{1}{2}$ in. diameter.

A full hook takes three seconds' bending time. It is also equipped with accessories for bending angle loops in one operation on mild steel reinforcement up to 1 in. diameter.

HOOPS & SPIRALS

We supply, at extra cost, an appliance (illustrated here) for use with RAS.40 and ARD.50 models for the bending of hoops and spirals. Bends radii of 11 in. and upwards and to any pitch of spiral.



Our Bending Equipment also includes the ARD.50 model—a double-disc machine for bending bars up to 2 in. diameter. We also supply, at extra cost, formers and backrests for special steel such as "Square Grip," "Twistee," etc., which can be fitted to the ARD.50 and RAS.40 models. Full details are available on request. All machines are available for Sale or Hire.

CEMENT & STEEL, LTD., SECOND AVENUE, CHATHAM, KENT

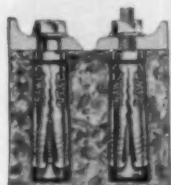
Telephone: Chatham 45580.

Telegrams & Cables: Cembelgi, Chatham.

A **RAWLPLUG** HEAVY DUTY FIXING DEVICE**RAWLBOLTS**

There is no waiting for cement to harden when you use Rawlbolts. The holes are drilled with a Rawltool to the exact size, the Rawlbolts dropped in and after the machine has been positioned the bolts are tightened. The expansion of the members locks the bolts in the holes. They cannot work loose through vibration or shock. The machine can be put into operation immediately.

Rawlbolts have earned a sterling reputation for strength and reliability throughout the world—they are used by the million every month. Rawlbolts grip by *expansion*—their strength as a fixing is based on the enormous compressive strength of concrete itself.

**RAWLBOLTS ARE MADE IN TWO TYPES**

For fixing heavy machinery to floors there is the Loose Bolt type of Rawlbolt which enables the machine to be slid into position after the Rawlbolt has been inserted. For wall fixings use the Bolt Projecting type which will position the fixing before tightening up.



Please write for Chart and descriptive literature.

Tools that save time. For hole boring there is a big range of high efficiency Rawlplug tools for use by hand, electric and air power.

**RAWLDRILLS**

For hand boring for Rawlbolt sizes A to G.

**DURIUM MASONRY DRILLS**

For use in hand and electric drills for Rawlbolt sizes C to G.

**DURIUM HAMMER DRILLS**

For use in electric hammers for Rawlbolt sizes C to J.

STARDRILLS

For hand boring for all Rawlbolt sizes.

**TRIFORM DRILLS**

For use in electric hammers for Rawlbolt sizes C to K.

**P. H. BITS**

For use in pneumatic hammers for Rawlbolt sizes E to K.



B545

RAWLPLUG CO. LTD., CROMWELL RD., LONDON, S.W.7. The World's Largest Manufacturers of Fixing Devices

Steel Reinforcement

. . . bent . . . bundled . . . labelled

Delivered to site ready for fixing •
No loss of time in checking and sorting material • No loss of material due to prolonged storage on site •

A complete service of
DESIGN, FABRICATION AND FIXING
for all types of Reinforced Concrete
Construction.

T. C. JONES
AND COMPANY LIMITED
REINFORCEMENT ENGINEERS

HEAD OFFICE: WOOD LANE, LONDON, W.12

Telephone: SHEpherds Bush 2020

SOUTH WALES OFFICE:

2 PIERHEAD CHAMBERS, BUTE STREET, CARDIFF

Telephone: Cardiff 28786

REINFORCEMENT DEPARTMENT:

17 BUCKINGHAM PALACE GARDENS, LONDON, S.W.1

Telephone: SLOane 5271

WORKS: Shepherds Bush, London. Neasden, Middlesex. Treorchy, Glamorgan

THE
600
GROUP
OF COMPANIES

All reinforcement enquiries please, to: 17 Buckingham Palace Gardens, London, S.W.1



TELECRETE

HYDRAULIC CONCRETE TIPPER



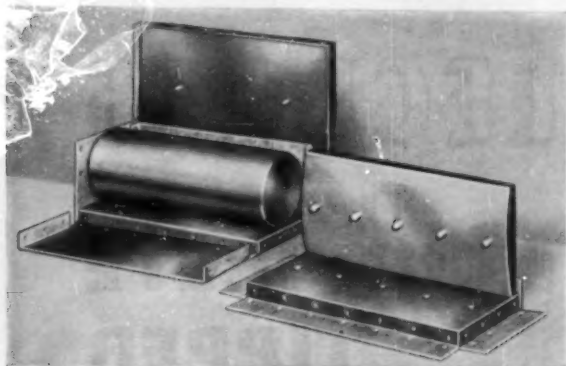
Designed for strenuous full-time work on all kinds of building sites, the Telecrete has been proved both efficient and economical for transporting ready-mixed concrete from a central mixing plant. The sturdy hydraulic controls are easy to operate. Ideal for public works contractors.

*Illustrated literature available
on request.*

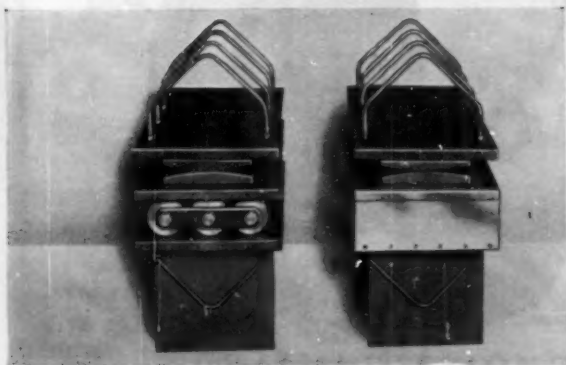
TELEHOIST LIMITED
TELEHOIST WORKS • CHELTENHAM • GLOS



Bridge Bearings by WESTWOODS

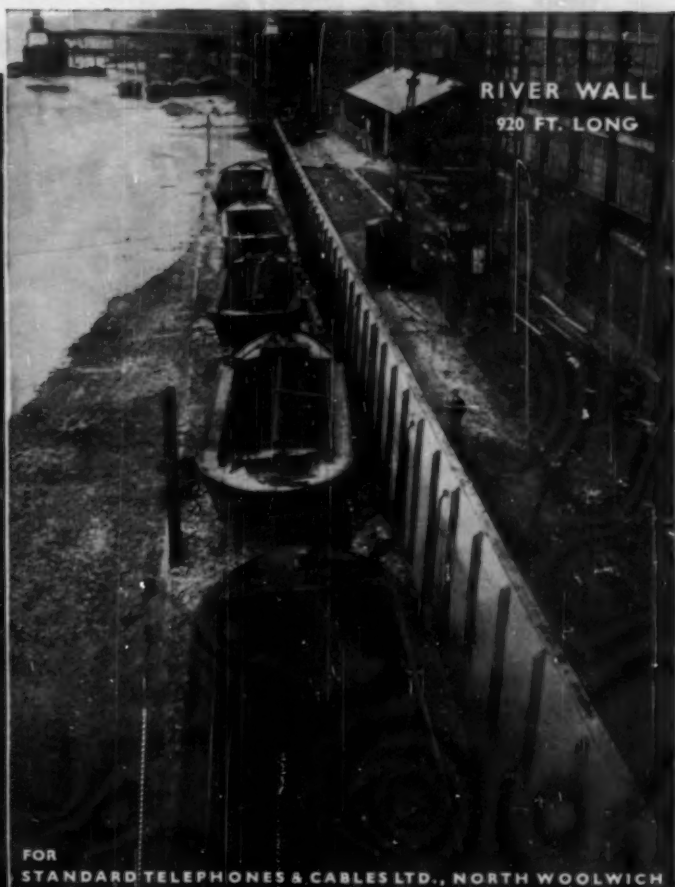


Illustrated are a few examples of various Bridge Bearings recently constructed by Westwoods.



Bridge and Constructional Engineers, Manufacturers of Mechanical Grabs, Pressed Steel Troughing and Sheet Metal Equipment. Steel Stock Holders.

JOSEPH WESTWOOD & CO. LTD.
 NAPIER YARD, MILLWALL, LONDON, E.14 Phone: EASt 1043



PETER LIND & CO LTD

ROMNEY HOUSE, TUFTON STREET, LONDON, S.W.1

TELEPHONE ABBEY 7361

UNI-TUBE

PLIABLE STEEL TUBING

Ducts for stressed concrete . . . labour saving . . . easy to install . . . outer corrugation gives a perfect bond to the surrounding concrete . . . the inside of the tube is smooth to facilitate the passage of bars or cables and allows free flow of grout.

Supplied in $\frac{1}{8}$ " up to 6' i.d.

As approved and supplied for the Lee-McCall, Freyssinet and Gifford-Udall systems. Also suitable for other systems and designs.

FOR
STRESSED
CONCRETE

UNI-TUBES LTD

Enquiries to London Office:

9 South Molton Street, W.1 Telephone: Mayfair 7915

Works: Alpha Street, Slough. Telephone: Slough 25476 8

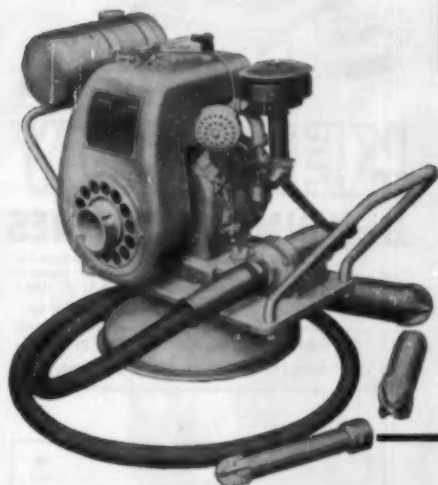
Supplied
to leading
contractors
throughout
the world.



Fast, efficient (150 G) compaction of harshest mixes with

JOHNSON

POKER TYPE
CONCRETE VIBRATORS

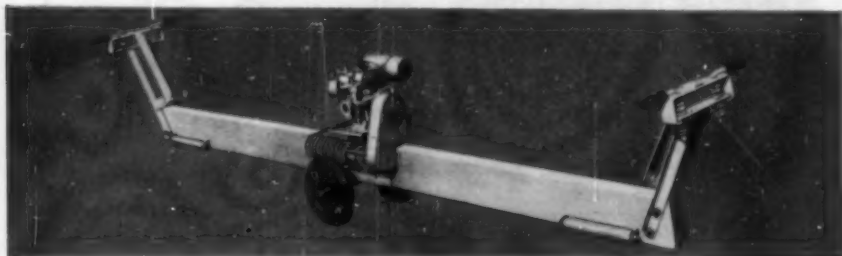


An ability to handle harshest mix combines with maximum ease of maintenance in the Johnson Model III Concrete Vibrator. Power unit is a 4 h.p. model 40 Villiers petrol engine, a Lister Diesel engine or an electric motor. Three interchangeable pokers ($1\frac{1}{4}$ ", $2\frac{1}{4}$ " and $3\frac{1}{4}$ " dia.) give 10,000 v.p.m. with acceleration up to 150 G. A ball-bearing turn-table moving through 360° on a dished, anti-vibration base increases flex-shaft life. Write for literature.

JOHNSON

TAMPING AND SCREED-
BOARD VIBRATORS

This single vibrating unit will vibrate and help propel tamping boards up to 20'. Johnson Tamping and Screed-Board Vibrators are a great advance over the old method of hand-tamping concrete road or floor slabs. They are easily operated by unskilled labour, are inexpensive and easy to maintain, and do not require the elaborate preparation needed by big mechanical road machines. Write for details.

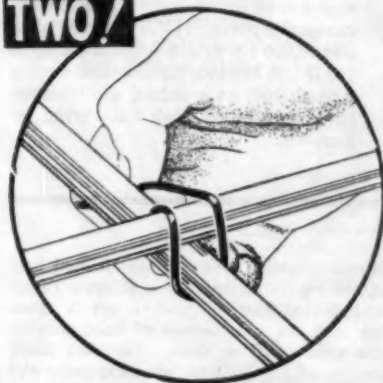


G. H. JOHNSON (MACHINERY) LTD.
ADSWOOD · STOCKPORT · CHESHIRE

Tel.: STOCKPORT 2642/5
London Tel.: Prospect 7671

Grams: "Machinery", Stockport
Glasgow Tel.: Kilmacolm 558



ONE...**TWO!**

'STABIL' BINDERS

ARE GREAT LABOUR SAVERS

In one simple action they fix reinforcing rods as though welded. No slipping. No "fiddling" with wire. No tools to get mislaid. Any workman can use them. Made in all sizes for binding $\frac{1}{4}$ -inch up to $1\frac{1}{2}$ -inch rods. Give "Stabil" Binders a trial and judge for yourself.

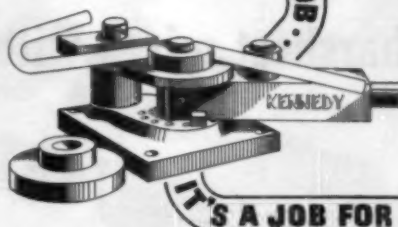
- SEND TO-DAY for demonstration samples and prices.

HUNTLEY & SPARKS LTD

DEBURGH RD., S. WIMBLEDON, S.W.19

Phone: Liberty 2446

IF IT'S A BENDING



KENNEDY

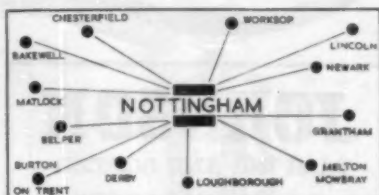
REGISTERED TRADE MARK

BENDING MACHINES

... featured above is the 1212 Bar bending machine for the accurate and rapid cold bending to precise measurement of mild steel reinforcing bars of up to $\frac{1}{2}$ " diam.

For full particulars of all Kennedy benders write to :-

**W. KENNEDY LTD., STATION WORKS,
34 WEST DRAYTON, MIDDX. West Drayton 2084**



Trent Gravels

10,000 tons per week
Washed & Crushed $1\frac{1}{2}$ in. to $\frac{1}{4}$ in.

We are the leading suppliers of high-class concrete aggregates in the area shown above. Prompt deliveries guaranteed and keen competitive prices quoted. Send for samples and prices.

TRENT GRAVELS LTD

ATTENBOROUGH

NOTTS

Telephone: Beeston 54255.

"CONCRETE SERIES" BOOKS ON CONCRETE

For a complete catalogue giving prices in sterling and dollars, send a postcard to:
CONCRETE PUBLICATIONS, Ltd.
14 Dartmouth St., London, S.W.1



Pre-planning smoothes and speeds building progress. Often it suggests modifications to constructional details that mean quicker building. Always it means fewer snags, more control, and it gives you your building on time and within your budget.

Ideas become concrete when

WATES BUILD

WATES LTD *Building & Civil Engineering Contractors*

HEAD OFFICES • 1258/1260 LONDON ROAD • S.W.16 • Telephone: POLLARDS 5000
LONDON DUBLIN NEW YORK

COPPER STRIPS

for expansion joints

All Reinforced Concrete Engineers recognise the advantages of using copper strips for sealing joints in concrete work. Copper is ductile, will not crack under repeated bending, is non-corrosive and is unaffected by wet concrete. We specialise in the supply of perforated copper strips of all required lengths and widths for expansion joints, and shall be pleased to submit prices against detailed specification.



ALEX J. CHEETHAM LTD.

MORTON STREET • FAILSWORTH • MANCHESTER

Telephone: FAIlsworth 1115/6

DS. 14

accurate particle size analysis

Vibration alone or hand shaking is not sufficient for accurate particle size analysis of materials. Vibration alone is more inclined to aggregate the particles. The Inclyno Test Sieve Shaker ensures perfect segregation of the various particle sizes in the shortest possible time having a double movement of gyrating and jolting the test material.

The Inclyno Test Sieve Shaker is an essential unit for all laboratories and is standard equipment in many government laboratories, nationalized industries and industry in general.

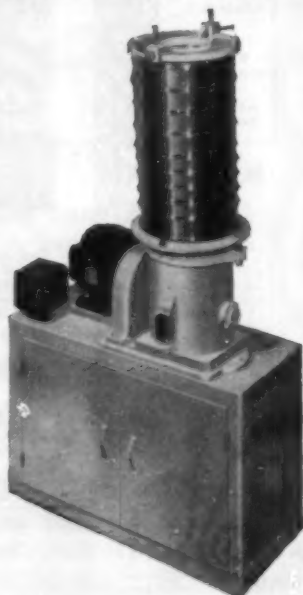
Operated by a fractional h.p. motor and supplied complete with automatic time switch covering test periods up to 60 minutes. Models available for all sizes of standard test sieves.

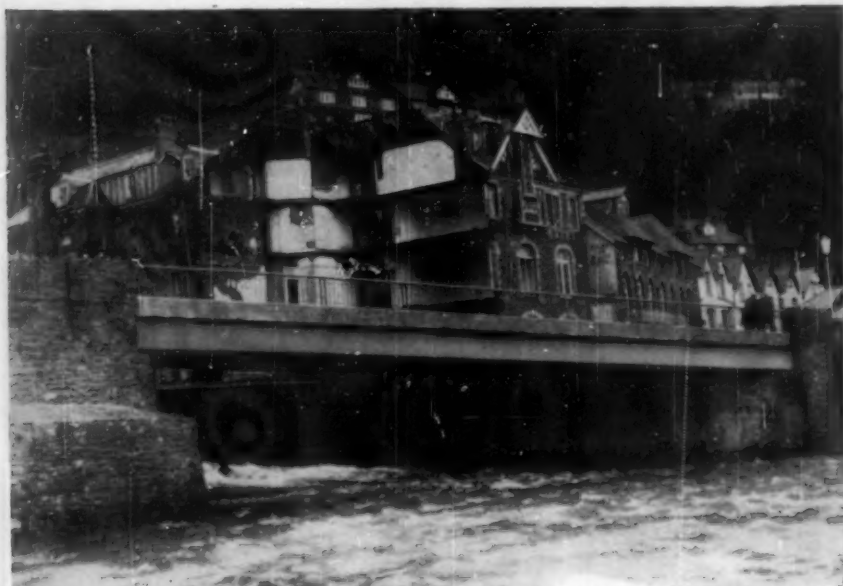
INCLYNO

TEST SIEVE SHAKER

Write or telephone Crawley 25166 for List IN 5012

THE PASCALL ENGINEERING CO. LTD.
GATWICK ROAD • CRAWLEY • SUSSEX

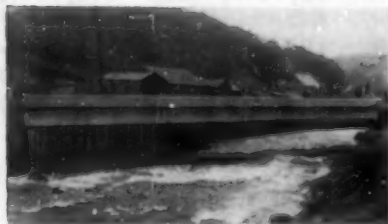




*High Street Bridge,
Lynnouth*

**McCALLS "MACALLOY"
PRESTRESSING STEEL
for Concrete Bridges in North Devon**

Bulletin No. 11, available on request, gives full details of the use of McCalls Macalloy Prestressing Steel in the construction of bridges to replace those destroyed in North Devon by the floods of August 1952 (Devon County Council Surveyor: R. B. Carnegie, Esq., C.B.E., M.I.Mun.E., F.I.H.E.)



Barbrook Bridge



Hillsford Bridge

McCALLS MACALLOY LIMITED

TEMPLEBOROUGH

SHEFFIELD P.O. BOX 41

Tel: ROTHERHAM 2076 (P.B. EX. 8 LINES)

LONDON OFFICE: 8-10 GROSVENOR GARDENS, S.W.1 Tel: SLOANE 0428

Also at Birmingham and Portsmouth

GLASCRCRETE

VARIABLE
GRID
WINDOW

at

Willenhall
Comprehensive
School, Staffs.



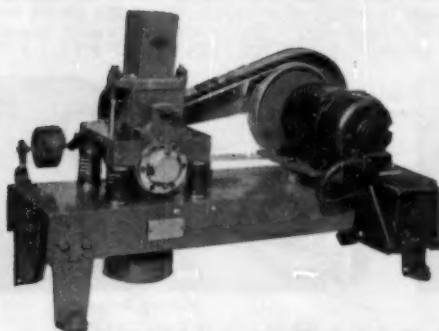
A. C. H. Stillman, Esq., F.R.I.B.A.
County Education Architect

Reinforced Concrete and Glass

BY

J. A. KING & Co. LTD. 181 Queen Victoria Street, E.C.4
Telephone: CENTRAL 5866 (5 lines)

"CAPCO" H. F. VIBRATOR



for compacting mortar cubes
for Compression Test B.S.
12/1947, B.S. 915/1947,
B.S. 146/1947, B.S. 1370/
1947. New type automa-
tic control—optional. The
vibrator illustrated in the
B.S. was built in our works.

The "CAPCO" range of con-
crete testing apparatus also
includes Cube Moulds; Slump
Cones; Tensile, Vicat, and Cylind-
rical Moulds; Tile Abrasion
Machines; Compacting Factor
Apparatus.

Full details on request.

CAPCO (SALES), LTD.

(Sole Agents for all
"Capco" Products)

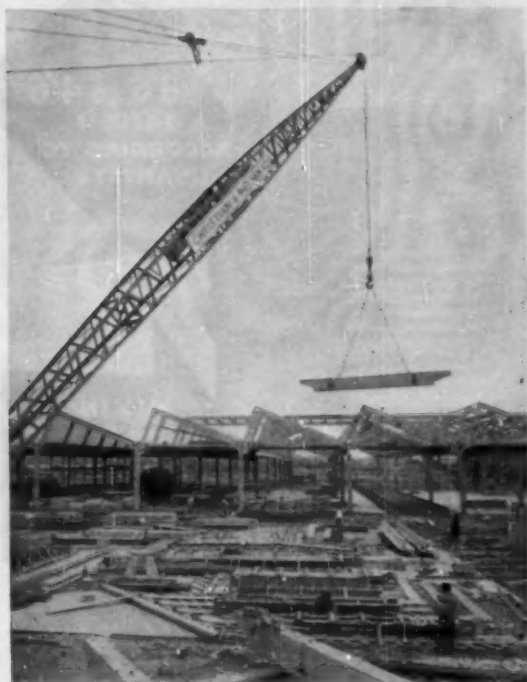
BEACONSFIELD ROAD, LONDON, N.W.10

Telephone: WILLESDEN 0067-8

Cables: CAPLUNKO, LONDON

CHRISTIANI & NIELSEN LTD

CIVIL ENGINEERS AND CONTRACTORS



**BATCHELORS
PEAS LTD**

**NEW
FACTORY**

**ASHFORD
KENT**

**PLACING
OF
PRECAST
MEMBERS**

*Photo by permission of Batchelors Peas
Ltd. and Unilever (Technical Division)
Ltd.*

**REINFORCED CONCRETE SPECIALISTS FOR CONTRACTS HOME AND
ABROAD**

BRANCHES IN 27 COUNTRIES OF THE WORLD



**ROMNEY HOUSE
TUFTON STREET
LONDON, S.W.1**

TELEPHONE: ABBEY 6614-7

HEAD OFFICE · COPENHAGEN

you can't beat this drum

**WATER -
PROOFER**

**3/6 to 4/6
A GALLON
ACCORDING TO
QUANTITY**

**QUICK
SETTER and
HARDENER**

**MIXING
RATIO**
Down to 26° F - 1:10
Down to 21° F - 1:8

**NO BUILDING
HOLD-UPS WITH
EVOSET 101 T.S.**

**COMPLETE
FROST
PROTECTION**
from 5/3 per
cu. yd.

EVOSET
101 T.S.
Frost Protective

FOR CONCRETE AND CEMENT MORTAR MIXES

Add EVOSET 101 T.S. to your mix and work throughout the winter. No costly stand-off time—no waiting for the weather. EVOSET 101 T.S. has no corrosive action on steel and will not affect properly embedded steel reinforcements. EVOSET 101 T.S. Frost Protective and Waterproofer can be used in conjunction with Evode Mortar Plasticiser and will not deteriorate in storage.



EVODE LIMITED · STAFFORD · ENGLAND

Telephone: 1590/1/2

Telegrams: Evode, Stafford

London Office: 1 Victoria Street, London, S.W.1 Telephone: Abbey 4622/3



THE
Mitchell
Construction Company



**Mass and Reinforced
Concrete Structures**

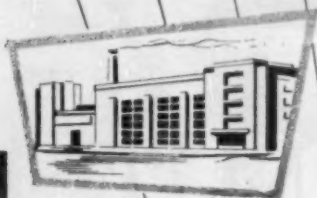
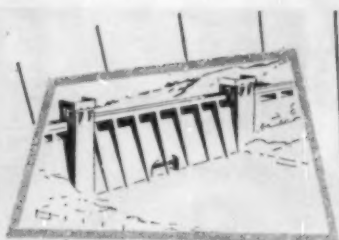
Contracts recently completed include two dams (illustrated above) for the Moriston Hydro-Electric Scheme at Loch Cluanie and Loch Loyne for the North of Scotland Hydro-Electric Board.

Consulting Engineers: Sir William Halcrow & Partners.

WHARF WORKS, PETERBOROUGH AND 7 GOWER STREET, LONDON, WCI

High Strain patented Steel Wire for Prestressed Concrete

Manufactured by-



LEE

OF SHEFFIELD

TRUBRITE STEEL WORKS - MEADOW HALL - SHEFFIELD
Tel. : Sheffield 387272

London Office: Stafford House, 40/43 Norfolk St., Strand, W.C. 2. Tel.: Temple Bar 7187 & 7188. Birmingham Office: 191 Corporation St., Birmingham 4. Tel.: Central 6801 & 6802

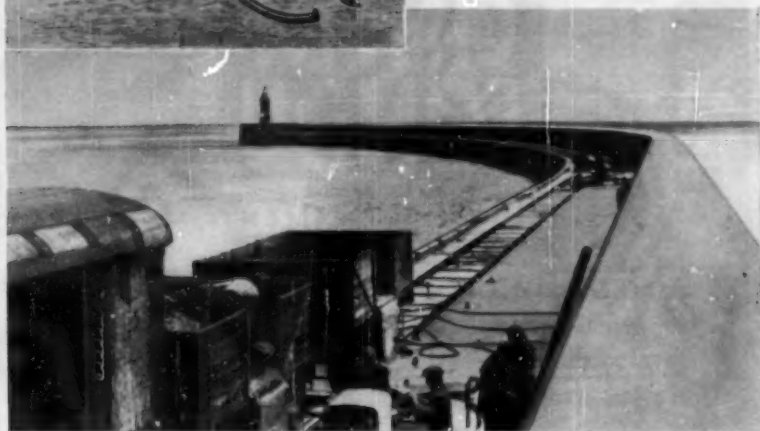
CEMENTATION PUTS NEW LIFE INTO NEWHAVEN BREAKWATER



The artist's illustration of Newhaven harbour has been based on an old print which was made in 1878 to record the construction of the breakwater.

Storms and heavy seas, pounding the structure throughout the years, have seriously reduced its stability. Cementation has come to the rescue and given the breakwater a new lease of life by its proved and tested methods of consolidating masonry and concrete structures.

The Cementation Co. Ltd. has the experience, the facilities and the resources to carry out this type of work in any part of the world.

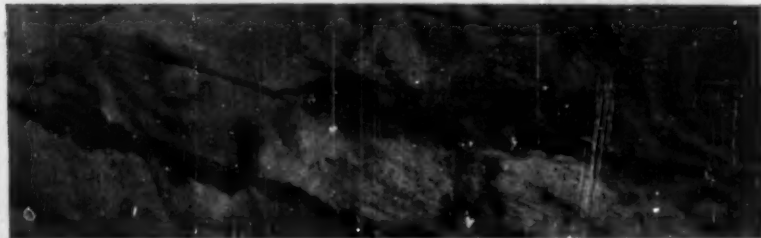


The **C**EMENTATION
COMPANY LIMITED

BENTLEY WORKS

DONCASTER

Tel.: Don. 54177-8-9



Concrete in **FOUL GROUND**



CIMENT FONDU concrete is highly resistant to practically all acidic ground conditions. It is also completely immune from any concentration of sulphates, even when in an immature state

Send for further information and special literature



Manufactured by

The Cement for Industry

**FOR SPEED : STRENGTH
RESISTANCE : REFRACTORINESS**

LAFARGE ALUMINOUS CEMENT COMPANY LIMITED

73, BROOK STREET, LONDON, W.1 Telephone : MAYfair 8546



THE ORIGINAL
STEEL TELESCOPIC SHUTTERING
used by Leading
CONTRACTORS
all over the World

*We invite you to write for
full particulars.*

It is the lightest Telescopic Floor Shuttering Center consistent with its great strength. Suitable for Spans from 2' 10 1/2" to 16', requires no propping or strutting. Easily erected, and dismantled. No obstruction for following trades.

TRIANGCO TELESCOPIC CENTERS

TRIANGCO LTD., Imber Court, EAST MOLESEY, Surrey.
Telephone: EMBurbrook 3300 (4 lines) Telegram: Trianco, East Molesey.



Free-

NEW REVISED

RAWLBOLT

reference chart

Your old R1144 standard reference chart is now obsolete, as the introduction of universal type shields has changed many of the dimensions of Rawlbolts. You will find the new revised chart, printed in colour, of immediate value for details of all sizes of Rawlbolts, depth and diameter of holes needed and sizes and types of tools available. Fill in the coupon *now* and have *your* copy sent you free and post free.

To Dept. J.E.S. The Rawlplug Company, Ltd.,
Cromwell Road, London, S.W.7

Please post me a copy of the completely revised
edition of the Engineers Rawlbolt Reference
Chart (Publication No. R1144).

Business Name.....

Address

.....

.....

(County).....

For the attention of.....

.....



B 537

THE RAWLPLUG COMPANY LTD
CROMWELL ROAD · LONDON · S.W.7

ALLT-NA-LAIRIGE PROJECT



Work in progress on the new Allt-Na-Lairige Dam.

Photo by courtesy of North of Scotland Hydro-Electric Board.
Consulting Engineers: Messrs. Babbie, Shaw & Morton

Construction by

Contractors for:
POWER STATIONS
DOCK AND HARBOUR
WORKS
HYDRO-ELECTRIC WORKS
REINFORCED CONCRETE
WORKS
TUNNELLING IN FREE AND
COMPRESSED AIR
EARTHWORKS
RAILWAYS
MAIN DRAINAGE
INDUSTRIAL BUILDINGS,
ETC.

**MARPLES,
RIDGWAY & PARTNERS**
LIMITED

CIVIL ENGINEERING CONTRACTORS

**2, LYGON PLACE, GROSVENOR GARDENS,
LONDON, S.W.1**

Telephone:
SLOane 0781

Telegrams:
Maripar, Sowest, London

THE FASTEST SCAFFOLDING

No nuts! No bolts! No Pins! No clips! And no tools needed! Mills Self-Lock frames just slot into one another — they can only be put up the right way. They are made of high-grade light-weight steel tube (the standard 5' x 2' frame weighs only 24½ lb.) and are easy to handle. A TWENTY FOOT TOWER CAN BE ERECTED IN JUST 3 MINUTES.

THE SAFEST AND THE

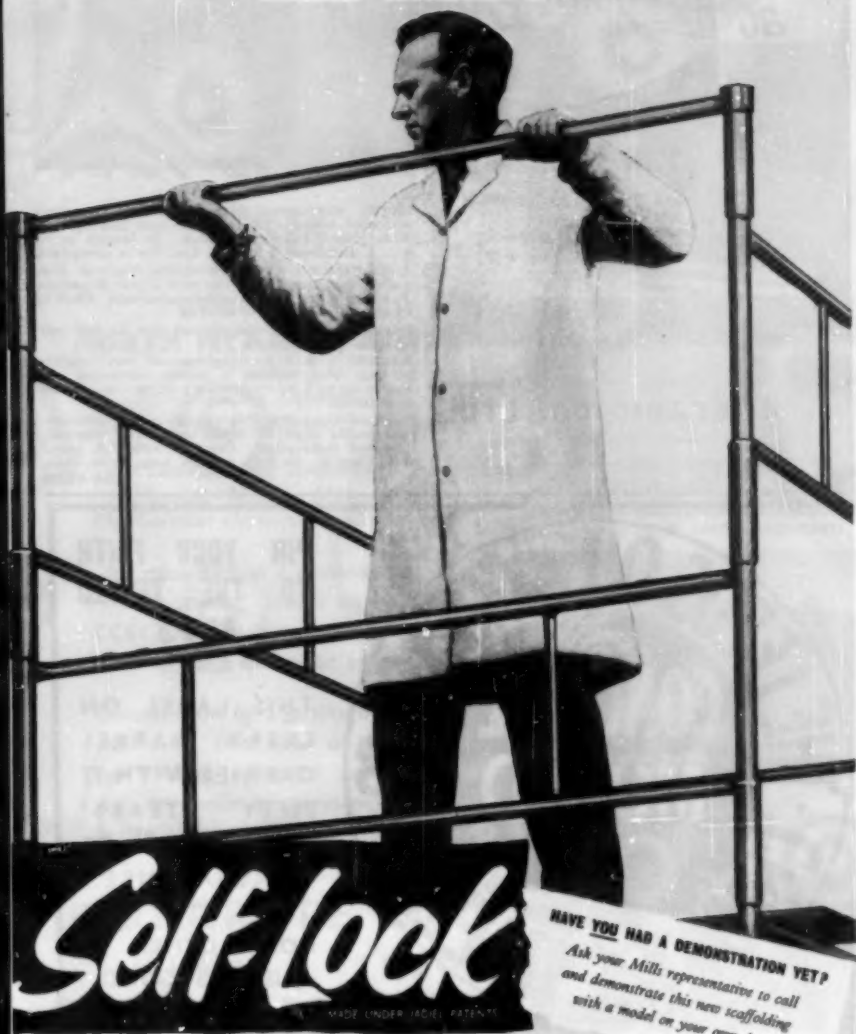
There's nothing to lose, nothing to work loose, no fastening devices to forget to tighten up. All load is taken on the upright members and the structure remains rigid under strains far in excess of those encountered during normal working conditions.

MOST ECONOMICAL IS

Lowest-ever labour costs!
Even the biggest job needs only a two-man team; one to handle the frames and one to put them in position. The scaffolding is self-aligning; frames stack compactly and transport conveniently.

THE NEW MILLS

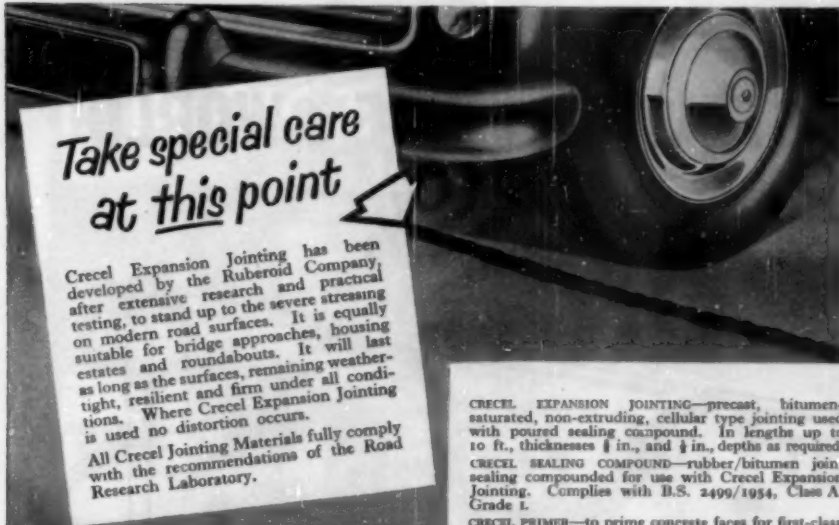
SYSTEM IN THE WORLD



Self-Lock

MADE UNDER U.S. PATENTS

HAVE YOU HAD A DEMONSTRATION YET?
*Ask your Mills representative to call
and demonstrate this new scaffolding
with a model on your own desk.*



*Take special care
at this point*

Crecel Expansion Jointing has been developed by the Ruberoid Company, after extensive research and practical testing, to stand up to the severe stressing on modern road surfaces. It is equally suitable for bridge approaches, housing estates and roundabouts. It will last as long as the surfaces, remaining weather-tight, resilient and firm under all conditions. Where Crecel Expansion Jointing is used no distortion occurs.

All Crecel Jointing Materials fully comply with the recommendations of the Road Research Laboratory.

Send for Data Sheets containing full Technical Information.

THE RUBEROID CO. LTD.

187 Commonwealth House
1-19 New Oxford Street, London, W.C.1.

CRECEL EXPANSION JOINTING—precast, bitumen-saturated, non-extruding, cellular type jointing used with poured sealing compound. In lengths up to 10 ft., thicknesses $\frac{1}{2}$ in., and $\frac{3}{4}$ in., depths as required.

CRECEL SEALING COMPOUND—rubber/bitumen joint sealing compounded for use with Crecel Expansion Jointing. Complies with B.S. 2499/1954, Class A, Grade 1.

CRECEL PRIMER—to prime concrete faces for first-class adhesion of compound.

RUBEROID C & E JOINTING—precast cork/bitumen jointing, used without a sealing compound. In lengths up to 6 ft., thicknesses $\frac{1}{2}$ in. to 1 in., depths as required.

Ruberoid Concreting Paper—high-quality, bitumen-impregnated paper for laying over entire road-bed. Rot-and damp-proof. Complies with B.S. 1521/1949, Class B. In Rolls 112 yds. long, 36 in. wide.

TGA CE232



**PIN YOUR FAITH
TO THE TESTED
BRAND.**

THIS LABEL ON
EVERY BARREL
CARRIES WITH IT
FIFTY YEARS'
EXPERIENCE OF
MANUFACTURE.

NONE OTHER IS
"JUST AS GOOD"

THE LEEDS OIL & GREASE CO.

Phone 22480

LEEDS, 10

'Grams: "Grease."

Colcrete PROCESS

MASS COLCRETE DAM

**GOGO FALLS
NORTH NYANZA, KENYA**

*Consulting Engineers :
Messrs. Brian Colquhoun & Partners*

*Commissioning Authorities :
Macalder Nyanza Mines, Ltd.
The Colonial Development Corporation*

A mass dam at a remote location containing 30,000 cu. yds. of COLCRETE using rock from excavations and site quarry as aggregate.

Construction by 3 ft. lifts of 100 cu. yds. using two sizes of aggregate for voidage reduction and rubble masonry walls as permanent shuttering.

**COLCRETE LTD
GUNLANE - STROOD
KENT**

Telephone : 78431 - 2 - 3



FOUNDATION GROUTING.



GROUTING-PIPES IN LARGE AGGREGATE.



GROUTING, MIXING & DISTRIBUTING PLANT.



SOUTH BANK EXCAVATIONS.



**For
better
concrete**

LISSAPOL N

—a stable surface-active agent which increases the workability of concrete without significantly affecting its strength. Lissapol N can be used : **either** to reduce the water content of the mix without affecting workability, thus giving stronger concrete **or** to reduce costs by allowing leaner mixes to be used without affecting the strength or workability.

Used on major projects throughout the world

APHROSOL FC

a powerful, economical foaming agent, for producing aerated concrete in a wide range of densities, suitable for building blocks, roof and floor screeds, etc.

Better thermal insulation

Easy handling • Reduced labour costs



Full technical data on request :

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1

D.756

Power for Scotland



PART of the vast hydro-electric programme for Scotland is at Loch Quoich, Inverness-shire, recently completed by Richard Costain Limited for the North of Scotland Hydro-Electric Board. This project includes a large rockfill dam (the first of its kind of

appreciable magnitude in Great Britain), two subsidiary concrete dams, a system of tunnels and shafts, a generating station, an aqueduct, a fish heck, and ancillary works. The Consulting Engineers were Sir William Halcrow and Partners.

Richard
COSTAIN
Limited

**Building & Civil Engineering
Contractors**

111 WESTMINSTER BRIDGE ROAD, LONDON, S.E.1. TELEPHONE: WATERLOO 4977

Middle East • Rhodesia • Nigeria • Canada

WATERTIGHT**LININGS****FOR****RESERVOIRS,****SWIMMING****BATHS, ETC.****LININGS****FOR****TUNNELS,****SEWERS,****TANKS.**

*Specialists in the Repair and Reconditioning of
Reinforced Concrete Structures, etc.*

THE

Telegrams :

Gunito

Hitchin

Telephone :

Hitchin

4371

GUNITE

CONSTRUCTION CO. LTD

WESTERN HOUSE, HITCHIN, HERTS.



**DELIVERED DIRECT TO ANY
CONTRACT BY MOTOR LORRY.**

Quotations on Application.

Telephone: Paddington 2024 (3 lines).

WASHED

**BALLAST, SAND, SHINGLE &
Crushed Aggregate for Reinforced Concrete**

WILLIAM BOYER & SONS, LTD.

Sand and Ballast Specialists,

**IRONGATE WHARF,
PADDINGTON BASIN, W.**

MEMBERS OF B.S. & A.T.A.

BARS for REINFORCEMENT

BARS in sizes from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. Mild
Steel 28-33 tons Tensile cut to lengths.

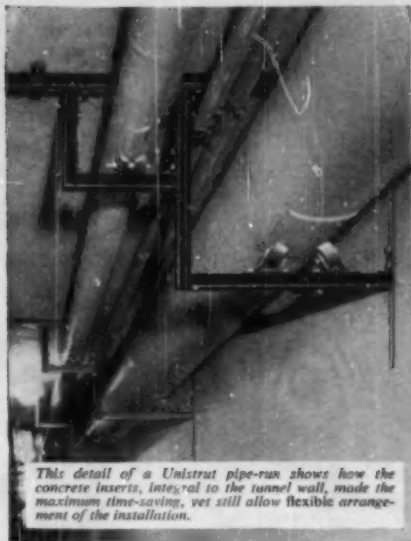
BARS bent to schedule.

BARS for prompt delivery to site at competitive prices.

Send your inquiries to

PASHLEY & TRICKETT • LTD.

STOKE STREET, SHEFFIELD, 9. Telephone: 41136-7. Telegrams: "PET" SHEFFIELD, 9



BUILT IN FLEXIBILITY SAVES YOU MORE!

UNISTRUT

CONCRETE INSERTS

Placed when the concrete is poured
accept fixtures at any point

Unistrut Concrete Inserts have many special advantages—practical as well as economical. Available in runs up to 20ft, they form an integral part of the building structure, yet allow the same infinitely variable insertion of fittings as the basic Unistrut system. They drastically reduce the amount of detail drawing required for a given installation, and give greater convenience—as well as reducing cost—when alterations or extensions are to be made.

Unistrut, developed in the United States to cut onsite costs, is a simple system of strong steel channeling, with a rapid self-locating nut and bolt assembly, which carries a vast range of fittings—for pipe, cable and conduit runs; storage racking; electrical fitting (including fluorescent trunking).

It will pay you to know about Unistrut before you plan that new project. May we send you details?



Please write to:

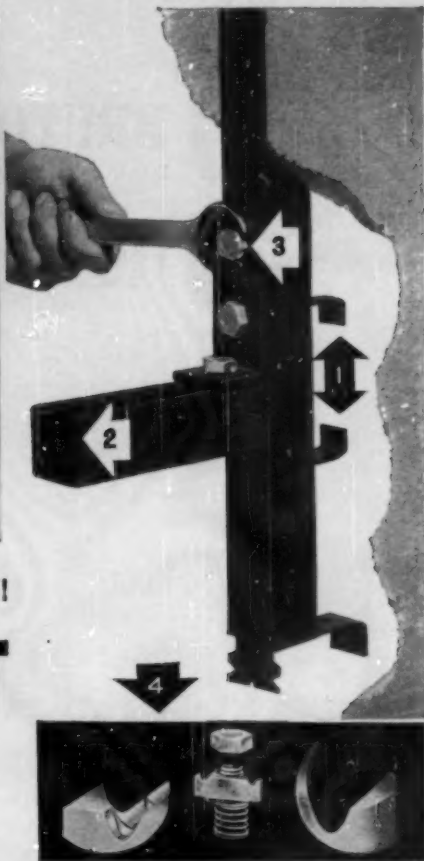
[C.C.E.]

UNISTRUT division of Sankey-Sheldon Ltd. Dept.

46 Cannon St., London, E.C.A. Telephone: City 4477

Telegram: SANKESHEL, CANNON-LONDON

UNI 7589



BUILT-IN UNISTRUT SYSTEM

1. CONCRETE INSERT, SOLIDLY ANCHORED.
2. BOX-SECTION STRENGTH.
3. CONTINUOUS ENTRY FOR FITTINGS.
4. SELF-LOCATING NUT ASSEMBLY.
5. COMPREHENSIVE RANGE OF FITTINGS.

Unistrut channel (including concrete inserts) is formed in cold-rolled 12 or 16 gauge steel. A self-locating nut, placed anywhere along the channel, remains in place while the bolt is inserted—one hand is always free. Serrated grooves in the nut "bite" home on the channel lip. This tough, positive assembly secures maximum speed and strength, yet allows infinitely variable adjustment.

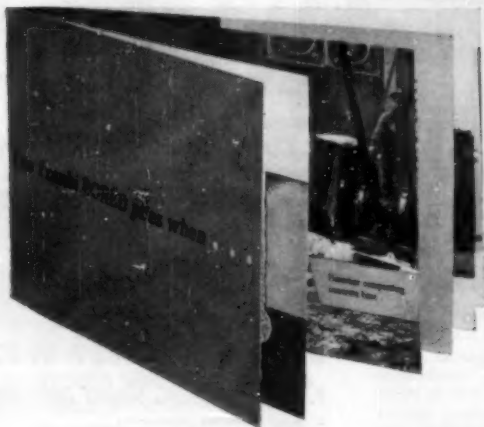
6-10 BRUTON STREET

LONDON, W.1

130 Franki Bored piles were installed on this site to depths averaging 30 ft. below ground level. These piles were guaranteed to carry working loads of 30 tons per pile. One pile was tested to a 50% overload and to the satisfaction of all parties concerned.

BUILDING ARCHITECT:
Cecil H. Elsom, F.R.I.B.A.

CONSULTING ENGINEERS:
S. H. & D. E. White



OUR ILLUSTRATED BOOKLET
OF TECHNICAL INFORMATION
WILL BE SENT ON REQUEST

FRANKIPILE

THE FRANKI COMPRESSED PILE CO. LTD. • 39 VICTORIA STREET • LONDON SW1 • CABLES FRANKIPILE SOWEST LONDON
AND IN AUSTRALASIA • BRITISH WEST INDIES • IRAQ • RHODESIA • S. AFRICA

67



PRESTRESSED CONCRETE UNITS

FORMING

TRUNK ROAD BRIDGE

Photograph by
permission of
Lincolnshire
C.C.

ANOTHER

ANGLIAN

PRESTRESSED PRODUCT

PYLONS · PILES AND
SHEET PILES · ROAD
AND RAIL BRIDGES
ROOF & FLOOR BEAMS

ANGLIAN BUILDING PRODUCTS LTD · LENWADE 15 · NORWICH

Tel
Gr. Witchingham 391

GUNITE SPECIALISTS

W.M. MULCASTER

& CO. (CONTRACTORS) LTD.

We invite inquiries for Gunité Linings and Renderings
for new or old structures of every kind in any part
of the country.

HASLINGTON

CREWE

Telephone : Crewe 2265-6.

Reinforced Concrete
DESIGN AND CONSTRUCTION

Cast Stone
AND PRECAST CONCRETE

Floors
IN SITU AND PRECAST

Granolithic Pavings

Staircases
IN SITU AND PRECAST

STUART'S
GRANOLITHIC CO. LTD.
FOUNDED 1840

LONDON

105 Baker Street, W.1.
Telephone : Welbeck 2525/6.

EDINBURGH

46 Duff Street.
Telephone : Edinburgh 61506.

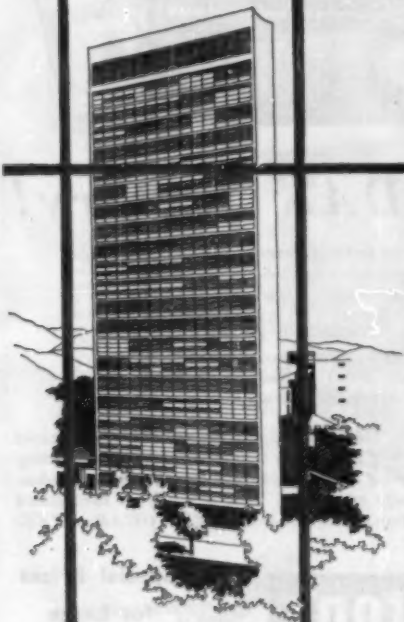
BIRMINGHAM

Northcote Road, Stechford.
Telephone : Stechford 3631/2.

MANCHESTER

Ashton Road, Bredbury, Stockport.
Telephone : Woodley 2677/8.

Maxweld reinforces it



Day by day, MAXWELD reinforces it: reinforces concrete and brickwork, reinforces its own reputation. MAXWELD fabric is made to BSS 1221 Part A—and closely controlled for quality from raw material onwards.

Do you need reinforcements?

Call up the MAXWELD man!

He'll tell you all about MAXWELD and what it can do for you. He'll tell you what type you need, how much you need, and how much it's going to cost you. He's backed by *Richard Hill's Design Service*, always ready to work out detailed plans and estimates.

He's backed by a first class product—and a first class delivery service. Call up the MAXWELD man—at Middlesbrough, London, Birmingham, Manchester, Leeds, Bristol or Glasgow.

Maxweld fabric

is manufactured by **RICHARD HILL LIMITED** (Established 1868)

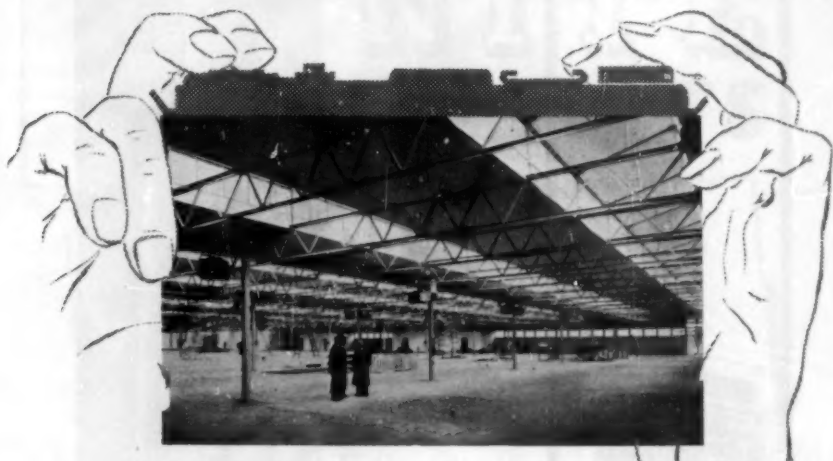
Newport Wire and Rolling Mills, Middlesbrough, Yorkshire.

Tel: Middlesbrough 2206

A MEMBER OF THE FIRTH CLEVELAND GROUP



No. 1 METALLIC LIQUID



In the new KODAK factory!

Kodak, the world's leading manufacturers of cameras and photographic equipment, continue to develop their vast organisation. Their most recent building project is a new factory at Stevenage—a picture of brightness and unrestricted space. Ideal conditions for precision work of high quality have been assured by mixing No. 1 Metallic Liquid in the floors to make them hard, waterproof, non-dusting and capable of withstanding heavy wear and tear.

For nearly fifty years, architects have specified No. 1 Metallic Liquid, the scientifically prepared admixture that makes concrete completely waterproof and dustless as well as accelerating the setting time. No. 1 Metallic Liquid is a necessity for waterproof cement renderings to walls and basements, mass concrete in retaining walls, foundations, flat roofs and tanks. You can rely on Lillington's No. 1 Metallic Liquid to give complete satisfaction because IT IS SOLD UNDER A GUARANTEE.

From
5/-
per Gallon

Lillington's
No. 1 METALLIC LIQUID

Special Prices
for Large
Contracts

WRITE FOR BOOKLET 56 GIVING FULL DETAILS

GEORGE LILLINGTON & CO. LTD.
WILLOW LANE, MITCHAM, SURREY

Telephone: MITcham 1066

FOR SCOTLAND: 42 HIGH STREET, GREENOCK

Reconstruction and widening of Commercial Road, Portsmouth, a reinforced concrete road reinforced with Matobar. Construction by City Engineer's Department, City of Portsmouth.



M^cCall's MATOBAR Welded Fabric Reinforcement for Roads

Another road improvement scheme using Matobar reinforcement. Trunk road A1 at Woolfox corner. Authority: Rutland County Council. County Surveyor: J. N. L. Sellick, M.I.Mun.E., M.I.H.E. Contractor: G. C. Munton, Ruskington, Lincs.



REINFORCEMENT



McCALLS MACALLOY LIMITED

TEMPLEBOROUGH

SHEFFIELD

Tel. : ROTHERHAM 207 (P.B. EX. 8 LINES)

LONDON OFFICE: 8-10 GROSVENOR GARDENS, S.W.1 Tel : SLOANE 0428

Also at Birmingham and Portsmouth



Cold weather
may bring joy to
some—but not to the
builder and contractor
with urgent concrete work
in hand. By taking special
precautions, however, one of which
is to use '417 Cement', expensive delays
can be avoided, even in severe
weather conditions. Please write
for booklet giving full details.

'417 cement'

QUICK SETTING—EXTRA-RAPID HARDENING



THE CEMENT MARKETING COMPANY LTD

Portland House, Tothill Street, London, S.W.1.

G. & T. Earle Ltd., Hull.

The South Wales Portland Cement & Lime Co. Ltd., Penarth, Glam.

BRITISH CEMENT IS THE CHEAPEST IN THE WORLD



**operation "reconstruction"
at GALLIONS LOCK**

CONTRACTOR: JOHN MOWLEM AND CO. LTD.
ENGINEER: G. A. WILSON, ESQ., M.ENG., M.I.C.E., M.I.MECH.E.
CHIEF ENGINEER, PORT OF LONDON AUTHORITY.

In the reconstruction of Gallions Lower Entrance Lock, Royal Albert Dock, John Mowlem and Co. Ltd. used Thamesply Plywood Shuttering for three important reasons: its lightness speeds erection and manhandling; it produced a fine, clean finish; and it can be re-used many times—in this case OVER FIFTY USES, which is not exceptional.

Thames-Celply, the specially impregnated rot- and insect-resistant plywood, is also available for all exterior uses.

JOHN MOWLEM & CO. LTD.
once again chose



PLYWOOD SHUTTERING

(Phenol Bonded "W.B.P." Test)
W.B.P. means Weather and Boil Proof

Supplied only through the usual trade channels

THAMES PLYWOOD MANUFACTURERS LIMITED

Harts Lane · Barking · Essex · Telephone: RlPpleway 5511



use the **A.B.**
SERVICE
for concrete work

SHUTTER PANELS

All sizes and types

ADJUSTABLE SHORES

for floor and beam support

ADJUSTABLE CENTRE FORMS

for floor support

SHUTTERLOCK WALING CLIPS

for bracing with scaffold tube and locking the panels together, eliminating nuts and bolts in shuttering. Tremendous saving in erecting and striking costs

COLUMN CLAMPS : BEAM CLAMPS

ROAD FORMS : TRENCH STRUTS

also design and manufacture Steel Moulds for Floor Beams, Piles, Railway Sleepers and all other precast concrete products

Let us solve your problems

A. B. MOULD & CONSTRUCTION CO., LTD.

92 WHITEHORSE ROAD

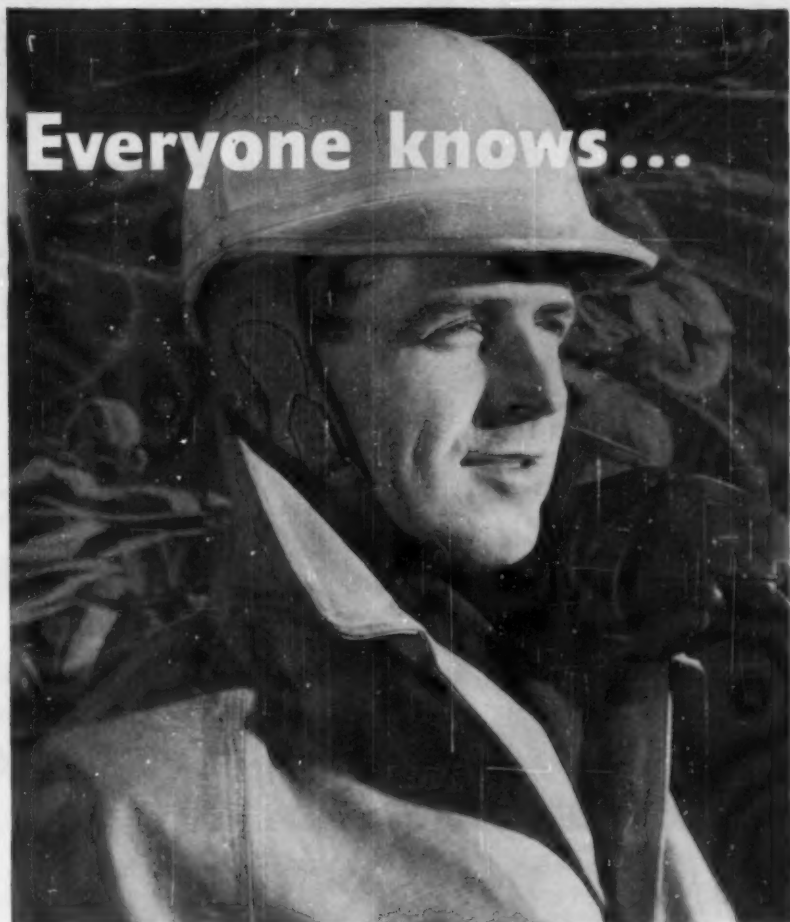
CROYDON

SURREY

Telephones : Thornton Heath 4947.

Telegrams : Abmould, Croydon.

WORKS: VULCAN WAY, NEW ADDINGTON, SURREY



Everyone knows...

● ● ● that road-racing has many dangers, and the high-speed motor cyclists know full well how greatly they depend on wire : wire helps them accelerate, helps them apply their brakes, takes current to their lamps—from saddle to speeding wheels they place their faith in wire.

● As on the race-track, so on the open road, SPENCER wire is providing reliability.

● Some of the Spencer enterprises : Steel, Copper and Aluminium Wire, Electrical Conductors, Welded Wire Mesh for reinforced concrete, Expanded Metal.



THE SPENCER WIRE COMPANY LIMITED, WAKEFIELD

Telephone : Wakefield 6111 (10 lines)

Telegrams : Spencer, Telax, Wakefield

Telex No. 55,200

Photograph by courtesy of
Messrs. Shockcrete, Ltd., Rye
House Works, Hoddesdon,
Herts.



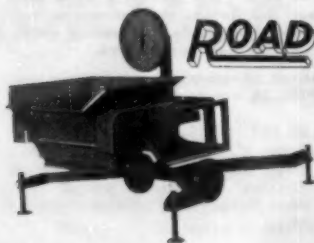
BULK CEMENT STORAGE PLANT WITH WEIGHBATCHER

Yet another instance of the versatility in the use of Weighbatching Equipment is this Bulk Cement Storage Plant, operating in conjunction with a 12 cu. yd. Hopper type Weighbatching Plant.

SINGLE BUCKET HAND-LOADED "SWING WEIGHBATCHER"

For mechanised outputs up to 20 cu. yds./hour. Aggregate storage hoppers of 12/40 cu. yds. with 2, 3, and 4 compartments as required.

Silos are supplied in capacities of 8 to 40 tons and the sectional construction allows extension at any time within these limits. Will operate equally well with hand-loaded Weighbatchers as with the hopper type plant.



ROAD MACHINES (DRAYTON) LTD.

West Drayton, Middlesex

Telephone: West Drayton
3221/2/3. Telegrams: 'Road
mach', West Drayton

Manufactured by the makers of
the "Drayton Dumper" and
the "Mono-Rail Transporter"



Expamet Reinforcements for concrete

The large range of "Expamet" Reinforcements provide a wide choice to suit all types of concrete construction. There are more than 100 standard variations and weights in "Expamet" Reinforcements from under 2 lb. to over 30 lb. per square yard.

"Expamet" Expanded Steel Sheet Reinforcement; "Expamet" Welded Fabric; Super "Ribmet" and other specialist materials can be adapted to meet reinforcement problems of all kinds, from solid slab decking and hollow floors, to light shell construction such as barrel vault and dome roofs. They are just as effective reinforcing concrete in precast units as in sea defence works.

We provide a complete Reinforcement Service for the design and supply of Reinforcement for all kinds of civil and constructional engineering.



"Expamet" Reinforcements are manufactured to comply with the British Standard 1221.

Expamet

Expanded Metal Products

**THE EXPANDED METAL
COMPANY LIMITED**

8a Burwood House, Caxton Street, SW1
Telephone: ABBey 7766

Works: West Hartlepool

Also at: ABERDEEN • BELFAST
BIRMINGHAM • CARDIFF • DUBLIN
EXETER • GLASGOW • LEEDS
MANCHESTER • PETERBOROUGH

CONCRETE PROOFING Co. LTD.

GUNITE SPECIALISTS

Expert advice and schemes submitted for gunite work of every kind. Complete information on the various uses of gunite will be gladly sent on request.

96, Victoria Street, Westminster, S.W.1

Telephone :
VICTORIA 7877 and 6275



Model VP 350-A (Swivel Base or Barrow Mounting)

Prompt Delivery. Highly Competitive Prices. Genuine Service. Re-Sale Terms Available.

★ We operate a 48-hour Shaft Repair Service for all makes. Write to-day for 8-page fully descriptive Catalogue. Agents throughout the world.

30 years' experience in the design and manufacture of flex-shaft tools.

THE FLEXIBLE DRIVE & TOOL CO., LTD.

EDENBRIDGE, KENT. Telephone : 3385-6

LONDON OFFICE : 17 QUEENSBERRY WAY, S.W.7. Telephone : KENSington 3583

For Greater Strength, Firmer Bonding
and Better Surfacing of Concrete—

"BAXTUL"

Regd. Trade Mark

British Made

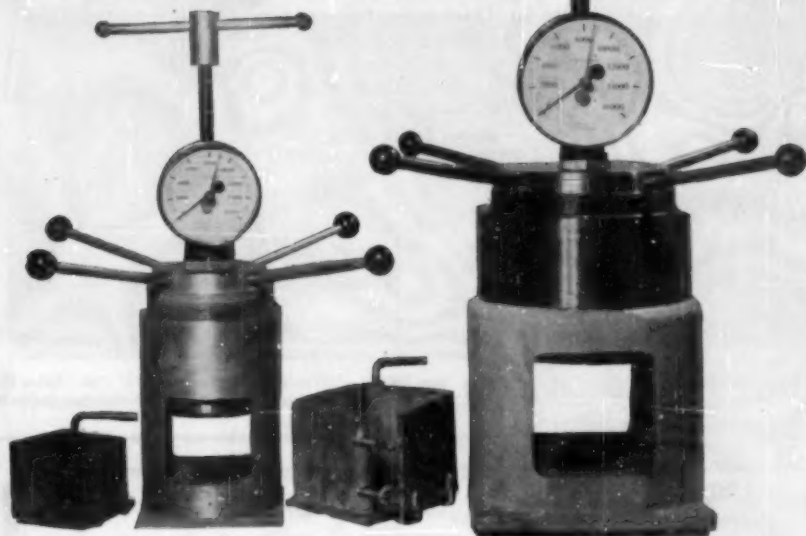
Extra-High Frequency

INTERNAL CONCRETE VIBRATORS

- The model illustrated here operates 9,000 to 15,000 Vibrations per minute from low flexible shaft speeds of 4,500 to 7,500 R.P.M.
- Petrol or Electric Drive.
- Robustly built throughout and backed by genuine service.
- Fitted centrifugal clutch, long-life flexible drive and Vibrator.

This unique machine, with quick-change additional tools, can also be used for : SURFACING, WET-RUBBING CONCRETE, GRINDING, DISC SANDING, AND DRILLING (up to 1½" in Concrete, 1" in Steel, and 2" in Wood)

APPROVED FOR SITE TESTING on all Government Departments' Contracts



4" PRESS AND MOULD

6" PRESS AND MOULD

in use all over the world

MILBANK-WELLS HYDRAULIC PRESS AND CUBE MOULDS FOR CONCRETE TESTING

Presses and Moulds in the 2 sizes for Testing 4 in. and 6 in. cubes
up to 16,000 lb. per square inch, complying with B.S. 1881.

MILBANK FLOORS LTD.

PRESTRESSED CONCRETE CONSTRUCTION

RIVER HOUSE, EARLS COLNE, ESSEX.

Telephone: Earls Colne 410

Manufactured for us by Horner & Wells, Ltd., Engineers, Chelmsford, Essex.

STENT

PRECAST CONCRETE PILES

Preferred by constructional engineers for their unchanging supremacy, Stent Precast Concrete Piles have proved their qualities wherever used.

AVAILABLE FOR
IMMEDIATE DELIVERY

*May we
forward full
details*

STENT PRECAST CONCRETE LTD. Sales Office : 1 Victoria Street, London, S.W.1 Tel. : Abbey 2573
Hd. Office & Works: Dagenham Dock, Essex Tel: Rainham (Essex) 780



THE "JOHN BULL" CONCRETE BREAKER

NEW "B.A.L." TYPE.

INCREASED:—

PENETRATION, RELIABILITY, LIFE.

REDUCED:—

VIBRATION, NOISE AND WEAR.

THESE ARE THE SALIENT FEATURES
OF THE NEW CONCRETE BREAKER

★ ★ ★

REAVELL & CO., LTD.
RANELAGH WORKS, IPSWICH.

TELEGRAMS: "REAVELL, IPSWICH."

TELEPHONE: 2124

Prestressed concrete *for economic bridge building*

PRESTRESSED
CONCRETE BRIDGE
BERNERA BRIDGE, STORNOWAY



Ever since prestressed concrete construction was first used in this country, designers, architects and civil engineers have specified "Wire by Johnsons". The reason is quality, built up on early experimental work with those specialist designers who studied and worked on the Continental development of this new building technique.

Johnsons have a long record of "Firsts" including indented wire for greater bonding and coils of 8 ft. diameter, from which the wire pays out straight.

After investigating the costs of various schemes it was decided to break away from the traditional methods of bridge construction and adopt the principle of prestressed concrete girders. This three-span prestressed design showed a saving of over £14,000 on the lowest offers.

* Some further details of this project and others are published in brochure form. Write for your copy now.

Sponsor: COUNTY COUNCIL OF ROSS AND CROMARTY, DINGWALL.

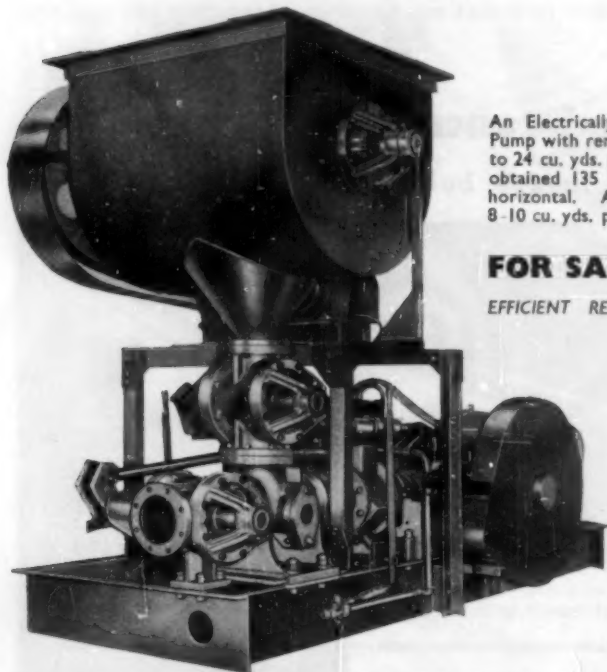
Designed by: BLYTH & BLYTH, M./M.I.C.E., CONSULTING ENGINEERS, EDINBURGH, in conjunction with J. A. SHAW, B.Sc., M.I.MUN.E., at the time COUNTY SURVEYOR, ROSS AND CROMARTY.

Contractors: A. A. STUART & SONS (GLASGOW) LTD., GLASGOW.

wire was essential-

***Johnsons* of course!**

Richard Johnson & Nephew Ltd., Manchester, 11



An Electrically Driven PC3 Concrete Pump with remixer. Capacities from 20 to 24 cu. yds. per hour. Ranges actually obtained 135 ft. vertical or 1,500 ft. horizontal. Also smaller model PC4—8-10 cu. yds. per hour.

FOR SALE AND HIRE

EFFICIENT RECONDITIONING SERVICE

CONCRETE BY PUMP AND PIPELINE

- The latest and most efficient method of placing concrete.
- Life of Pump practically indefinite: all essential surfaces in contact with concrete are renewable.
- Pumpable concrete must of necessity be good concrete.
- Pump and Mixing Plant can be located at the most convenient position within the pumping range.
- The continuous output of the Pump at a constant speed governs the working of the whole concreting gang.

THE REGISTERED TRADE MARK OF



THE CONCRETE PUMP COMPANY LIMITED

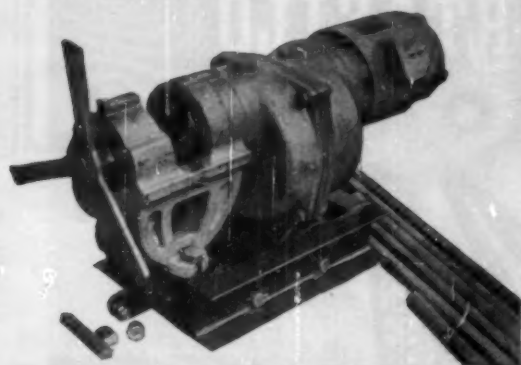
THE CONCRETE PUMP COMPANY LTD

4 STAFFORD TERRACE, LONDON, W.8

Telephone: Western 3546

Telegrams: Pumpcret, Kens, London

★ ENTIRELY NEW HYDRAULIC BAR CROPPER



THIS ALL-BRITISH

ALLAM

BAR CROPPER
is specially designed
for Precast Concrete
Makers and Rein-
forced Concrete
Contractors

MAXIMUM CAPACITY: Up to
1-in. diameter bars, or multiples
of smaller diameter bars, includ-
ing rounds, squares and flats.

Other types also available with capaci-
ties up to 1½" diameter bars.

E · P · ALLAM & CO. LTD.

LONDON: 45 Great Peter Street, S.W.1. • Telephone: Abbey 6353 (5 lines)

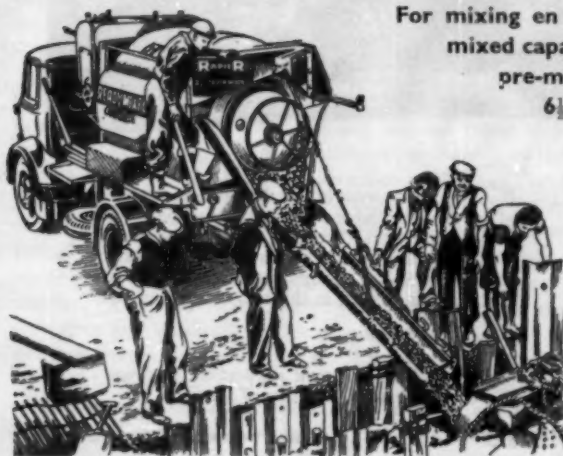
SCOTLAND: 39 Cavendish St., Glasgow, G.1. Tel.: South 0186. Works: Southend-on-Sea. Tel.: Eastwood 55243

RAPIER TRUCK MIXERS

and AGITATORS

For mixing en route 2½ and 4½ cu. yd.
mixed capacity. For agitating
pre-mixed concrete 3½ and
6½ cu. yds.

Also makers of a full range of
tilting and non-tilting mixers
and self-priming water pumps.



RANSOMES & RAPIER LTD · IPSWICH · ENGLAND

PORTASILO

for handling
cement
in bulk

A Type 201 PORTASILO at STEETLEY MAGNESITE CO. LTD., Pailiser Works, Hartlepool.

Contractors :
Brims & Co. Ltd.,
Newcastle.

Portasilo is the most highly developed equipment of its kind available. Incorporating the unique Pullwey mechanical cement man its use readily effects a saving of 17/- and over per ton of cement used. This equipment is now fully proved on hundreds of sites in this and other countries.

Covered by patents or patent applications in Great Britain and the Principal countries of the world.

PORTASILO LIMITED BLUE BRIDGE LANE, YORK Tel: 24872 (8 lines)

and at LONDON • BIRMINGHAM • MANCHESTER • GL/SGOW • BELFAST • DUBLIN

CONCRETE

AND

CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

Volume LI, No. 12.

LONDON, DECEMBER, 1956.

EDITORIAL NOTES

The Application of the Results of Tests.

THE testing of a few samples as a means of assessing the properties of a large number of the same product inevitably results in the acceptance of assumptions as truths. If we were to believe that every batch of concrete throughout a structure would have the same strength as that of small samples tested before the work started, or that all the reinforcement would be the same as the short pieces tested, we would assume that probability was certainty. We can predict that the sun will rise to-morrow because it has been known to do so regularly for so long that probability becomes certainty. In the case of other natural phenomena, such as the force of gales, the height of waves, degrees of heat and cold, and so on, records have been kept for a few years only; in such cases it is safe to assume that the possibility that the greatest recorded winds and waves and heat and cold will be exceeded is in fact a certainty. These are, of course, the reasons why factors of safety are used as precautions against unknown natural forces, unknown human fallibility, and unknown variations in processes that may be always the same in theory but are known to vary in practice.

According to our knowledge of the probability of differences in the properties of what are supposed to be the same products, or of the variations in mechanical processes, so the nature of tests and the use made of the results vary, or should vary, if they are to give a reasonably reliable guide to the properties of the remainder of the products or to the continuing uniformity of a process. There are, however, many differences, some of them not easily explained, in the numbers of samples tested and of using the results in the concrete industry. For example, British Standard Code of Practice No. 114 requires that in making his calculations an engineer may assume that the compressive strength of concrete will not be less than a certain value provided that the average strength of three cubes (the strongest and weakest of which do not vary by more than 15 per cent. from the average) made before the work starts exceeds the required strength in the work by about 15 per cent. This applies to all grades of concrete, including high-grade concretes. On the other hand, the specification of the Ministry of Works for "Quality Controlled Concrete" requires that twelve preliminary test cubes must all exceed the required strength by 15 per cent. The average of three cubes

and every one of twelve cubes are very different bases on which to assess the properties of concrete, and suggest that the Ministry of Works is much more sceptical of the probability of preliminary tests accurately predicting the strength of concrete made with the same materials and plant when placed in the work, even when supervision is very strict. The U.S.A. standard is also more stringent than the British, and requires that the average strength of four or more specimens be used as the criterion of the strength of the concrete in the work.

In the case of precast concrete products the tests differ according to the product. This is to be expected, for the strengths required in different products vary and the seriousness of the consequences of failure also varies. There are, however, some curiosities in the revised British Standards for precast products issued this year. In the standard for precast lintels the customer may select for a breaking-load test one lintel per hundred ordered, and this is the only acceptance test recognised. Porosity is ignored—the standard merely states that the maker should (not must) satisfy himself that the concrete is suitable for the purpose if the lintels are to be used in exposed positions, and there is no provision by which the customer can refuse to accept them if in his opinion the lintels are too porous for their purpose. The compressive strength required is a minimum of 2500 lb. per square inch at twenty-eight days. Standard designs for lintels for external use are given, including one 6 ft. $5\frac{1}{8}$ in. long by $4\frac{1}{8}$ in. wide with two $\frac{1}{2}$ -in. bars near the bottom, and this is coupled with a clause that the cover of concrete need be only $\frac{1}{4}$ in. Whether the bars are spaced to give as much cover as possible within this width, or whether the specified minimum cover is used, this is a surprisingly thin protection of such weak concrete, and one that few engineers would accept. It seems that the compilers of this standard are much too optimistic in their assessment of the probable durability of exposed lintels made to meet their requirements, and assume far too much in considering that its breaking strength at twenty-eight days is the only property considered to be important in a lintel.

The revision of the standard for paving flags requires that three flags be tested for orders up to 1000 sq. yd. (say, one flag in five hundred). If any of these samples fail to pass the test for transverse strength then three more may be tested, and if these pass the test then all the flags must be accepted. If it should happen that all three of the flags fail in the first test and all pass in the second, then the customer is expected to believe that all the flags are in accordance with the standard although it has been proved that half of the specimens tested have failed. In the case of the revised standard for concrete roofing tiles there is another variation in that the averages of test results are used. For example, in the permeability test three tiles may be tested out of ten thousand, and if their average impermeability meets the requirement they must all be accepted. In the absence of any limit of deviation, it could happen that two of the tiles were sub-standard and one sufficiently above the standard to enable the average to comply with it. In this case it would be assumed that ten thousand tiles complied with the standard, although tests showed the probability that two out of every three would not do so.

Engineers and contractors would be well advised to study British Standards carefully before specifying precast concrete units to comply with them, for the tests relate to products already made and perhaps delivered.

The Analysis of Frames with Non-prismatic Members.

THE COLUMN-ANALOGY METHOD.

By E. S. E. LYLE, B.Sc., A.M.I.C.E.

In this journal for June 1956 the writer described the use of the column-analogy method for the analysis of gable frames consisting of straight prismatic members. In the following the method is extended to the analysis of any type of single-bay frame of one story containing straight, curved, or non-prismatic members. The same notation is used.

The analogous areas and other properties of any straight prismatic members may be found by the method previously described. The properties of other members are found by finite integration. The member is divided along its axis into a convenient number of short sections, preferably, but not necessarily, equal in length. The lengths of the sections should be such that I does not change greatly or suddenly within the section, and i_x , etc., for the section should be so small in relation to I_x , etc., for the whole frame that they can be neglected. Each section may be considered as a short straight prismatic member with a moment of inertia equal to that at its mid-point. The frame may now be analysed in the usual way, the only difference being the increase in the amount of arithmetic due to the increased number of sections.

EXAMPLE I.—In a hinged frame with tapering columns (Fig. 1) it is assumed that the width of all the members is the same and that I may therefore be assumed to be proportional to d^3 where d is the depth at the point considered. If the width is not constant, I should be based on the actual cross sections. The member BC is dealt with as described in the previous article, and AB and CD are divided into six sections of equal length. The evaluation of I_y is shown in Table I, which shows that I changes quickest within section 1. At A it is 1, and at the top of the section it is 1.652. The width $1/I$ of the analogous column is 1 at A, at the mid-point of the section it is 0.771, and at the top 0.605. The value 0.771 is used in the calculations. A more accurate value would be the average (0.781), but the error is small, particularly as the section concerned lies close to the X-X axis and therefore has only a small influence on the final value

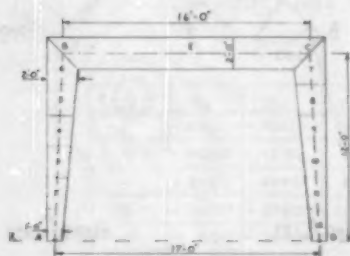


Fig. 1.

TABLE I.

Section	η_1	L	α	γ	$\alpha\gamma^3$
1	0.771	2.0	1.542	1.0	1.5
2	0.484	2.0	0.968	3.0	8.7
3	0.325	2.0	0.650	5.0	16.3
4	0.228	2.0	0.456	7.0	22.4
5	0.167	2.0	0.334	9.0	27.1
6	0.125	2.0	0.250	11.0	30.3
BE	0.125	8.0	1.00	12.0	144.0

250.3

$I_y = \frac{250.3}{2}$

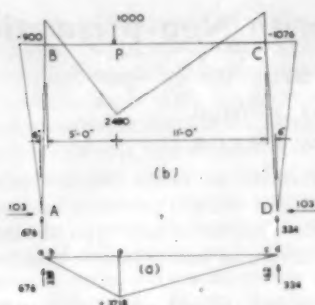


Fig. 2.

TABLE II.

Section	a	m	p=ma	y	py
1	1.542	28	43	1.0	43
2	0.968	84	81	3.0	243
3	0.650	141	92	5.0	460
4	0.456	197	90	7.0	630
5	0.334	253	85	9.0	765
6	0.250	309	77	11.0	847
B P	0.625	2028	1270	12.0	15240
P C	1.375	1940	2670	12.0	32040
7	0.250	148	37	11.0	407
8	0.334	121	40	9.0	360
9	0.456	94	43	7.0	301
10	0.650	67	44	5.0	220
11	0.968	41	40	3.0	120
12	1.542	13	20	1.0	20
					$M_y = +51696$

Point	m_x	m_y	m
B	+338	+1238	-900
P	+3718	+1238	+2480
C	+162	+1238	-1076

$$m = \frac{51696}{501} y = 103.2 y. \quad H = 103.$$

$$V_x = 676. \quad V_D = 324.$$

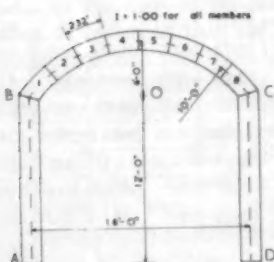


Fig. 3.

TABLE III.

Section	y_1	L	a	y	ay
AB	1.0	12.0	12.00	6.00	72.0
1	1.0	2.32	2.32	0.86	2.0
2	1.0	2.32	2.32	2.36	5.5
3	1.0	2.32	2.32	3.40	7.9
4	1.0	2.32	2.32	3.93	9.1
					21.28
					-47.5

$$\bar{y} = \frac{-47.5}{21.28} = -2.23$$

TABLE IV.

Section	a	x	y	ax^2	ay^2	$\frac{1}{2}$
AB	12.0	-8.00	-3.77	76.8	170.6	144
1	2.32	-7.24	-3.09	121.6	22.2	-
2	2.32	-5.48	-4.59	69.7	48.9	-
3	2.32	-3.41	-5.63	26.9	73.6	-
4	2.32	-1.16	-6.16	3.1	88.2	-
					989.3	547.5

$$A = 4256. \quad L = 1979. \quad I_y = 1095.$$

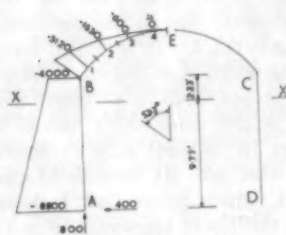


Fig. 4.

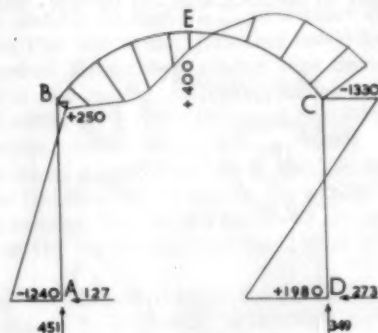


Fig. 5.

of I_y . The value of i_y for section 1 is $\frac{1}{12} \times 0.771 \times 2^3 = 0.257$ and for section 6 is 0.042; these are small enough to be neglected and the choice of six sections for each column is therefore reasonable. If twelve sections were used I_y would have been 512, that is a difference of about 2 per cent.

The frame is analysed in Fig. 2 and Table II for a vertical concentrated load. The static bending-moment diagram chosen (Fig. 2a) is that for a beam simply supported at A and D. The final moments are shown in Fig. 2b. If twelve sections were analysed, m_i would have been 101.4y instead of 103.2y, that is a difference of less than 2 per cent. It is seen, therefore, that the work involved in using a larger number of sections is not justified unless the frame is particularly important and the anticipated loads can be estimated very accurately, which is not generally possible.

EXAMPLE II.—A frame rigidly fixed at A and D and with a top member curved to a radius of 10 ft. is shown in Fig. 3. The elastic centre, which must lie on the Y-Y axis, is calculated in Table III and the properties of the analogous column in Table IV. In each case, due to its symmetry, only half the frame need be considered. The frame is analysed for an inwardly-acting radial load of 100 lb. per foot. The static bending-moment diagram chosen is that for the cantilever ABE (Fig. 4). The bending-moment at any point on the curved member at an angle α from the vertical through the centre of the arc is

$$m = wr^2(x - \cos \alpha) = 100 \times 10^2(x - \cos \alpha).$$

TABLE V.

Section	α	\bar{m}	p	x	y	px	py
A B	12.0	-4.000	-48.000	-8.00	-3.77	+384.000	+181.200
A B		-2.400	-28.800		-5.77	+230.400	+166.200
1	2.32	-31.20	-7.250	-7.24	-3.09	+52.500	-22.400
2	2.32	-16.30	-3.780	-5.48	+4.59	+20.700	-17.360
3	2.32	-6.00	-1.390	-3.41	+5.63	+4.740	-7.830
4	2.32	-7.0	-1.80	-1.16	+6.18	+1.90	-9.90
$P = -89.380$							$M_x = +692.530$ $M_y = +2988.20$
$m_i = -\frac{89.380}{42.56} + \frac{692.530}{1979} x + \frac{2988.20}{1095} y$							$H_A = 127$ $H_D = 273$ $V_A = 451$ $V_D = 349$
$= -2100 + 349x + 273y$							
Point	m_s	m_l	m	Point	m_s	m_l	m
A	-8800	-7560	-1240	5	0	-20	+20
B	-4000	-4250	+250	6	0	+630	-630
1	-3120	-3790	+670	7	0	+1060	-1060
2	-1630	-2760	+1130	8	0	+1270	-1270
3	-600	-1750	+1150	C	0	+1330	-1330
4	-70	-820	+750	D	0	-1980	+1980
E	0	-400	+400				

Therefore $M_B = 10,000(1 - \cos 53.2) = 4000$ ft.-lb. The vertical component of the total load is $100 \times 8 = 800$ lb. and the horizontal component $100 \times 4 = 400$ lb. Therefore $M_A = 4000 + 400 \times 12 = 8800$ ft.-lb. The indeterminate moment m_i , and hence the final moment m , is calculated in Table V and the final bending-moment diagram is shown in Fig. 5.

Prestressed Piles 132 ft. long.

PRESTRESSED concrete piles 131 ft. 8 in. long, made by the pre-tensioning method, were used in the reconstruction of a pier in San Francisco, U.S.A. Tenders showed that these were cheaper than precast reinforced concrete piles or timber piles with gunited tops.

The piles are octagonal in cross section and measure 1 ft. 8 in. across the flats. They have a hollow core of 11 in. diameter except for solid lengths of 4 ft. 6 in. at the top and bottom. The piles are prestressed by eighteen high-tensile steel wires of $\frac{1}{2}$ in. diameter. A prestressing bed 500 ft. long for making three piles at a time on each of four production lines was constructed fifty miles from the site, to which the piles were transported by barge.

The prestressing wires passed through slots in the steel points of the piles (Fig. 1) and were tensioned simultaneously by an hydraulic jack of 200 tons capacity to a stress of 175,000 lb. per square inch.

It was specified that the concrete (tested on cylinders) should have a strength of not less than 5000 lb. per square inch at 28 days and not less than 4000 lb. per square inch before the force in the wires was transferred to the concrete. A modified rapid-hardening cement was used, and the piles were steam cured for 24 hours and driven three or four days after they were cast.

Each pile weighed 16 $\frac{1}{2}$ tons and was lifted from four points of suspension 9 ft. 6 in. and 45 ft. 6 in. from both ends. They were driven by a floating rig with leads 120 ft. long, and the weight and fall of the hammer were such as to produce 32,500 ft.-lb. of energy. The 131 piles

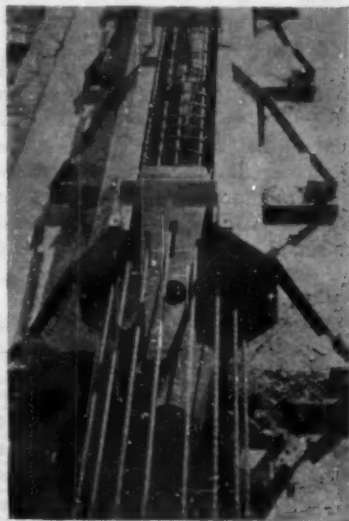


Fig. 1.

were driven to predetermined levels; this was possible because the level of the stratum of sand and gravel that supported the piles was known. The piles had a safe bearing capacity of from 60 to 70 tons, compared with the design load of about 50 tons. The piles were made and driven by Ben C. Gerwick, Inc., for the California State Harbour Commission. [The foregoing is abstracted from "Engineering News Record" for July 19, 1956.]

Facing a Dam by the Vacuum Process.

THE following describes the use of the vacuum concrete process for casting the concrete on the upstream face of Loch Quoich dam (*Fig. 1*), recently completed for the North of Scotland Hydro-Electric Board as part of the Garry hydro-electric works. The dam is 1100 ft. long and has a maximum height of 110 ft. A road 10 ft. wide extends across the top. The upstream face has a slope of about 1 in 1.3 and the downstream side 1 in 1.4. Watertightness is achieved by a concrete cut-off trench cut into the rock along the up-

on a timber gantry halfway up the face was used. The concrete was delivered by lorries carrying skips of 1 cu. yd. capacity to the foot of the dam.

On the second stage two fixed 7-tons derrick cranes with 120-ft. jibs were used (*Fig. 3*). These were first erected on the top of the dam at one end and 90 ft. apart; as the work progressed one crane was used to dismantle and re-erect the other 90 ft. farther along the face. Only ten hours were required to dismantle and re-erect a crane and only one day's work was lost

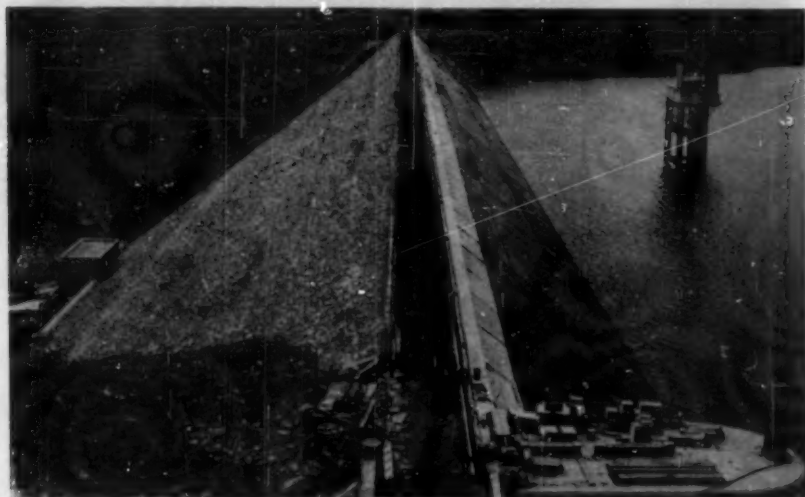


Fig. 1.—Loch Quoich Dam, Scotland.

stream toe of the dam and a reinforced concrete face 12 in. to 15 in. thick on the upstream face. The surface area of this face is 14,800 sq. yd. and, in order to reduce cracks due to shrinkage and settlement, construction joints are formed at a maximum spacing of 20 ft. in both directions; the joints have copper seals and a bituminous filler.

The face concrete was placed in two stages, the lower slabs comprising stage 1 and the remainder stage 2; this enabled impounding of the water to start before the top of the dam was finished.

For the first stage (*Fig. 2*) a 3-tons mobile derrick crane with an 80-ft. jib, travelling

when a crane was moved. Concrete was delivered by locos. pulling bogies carrying 1-cu. yd. skips and travelling on a track just downstream from the top of the dam and extending its full length; at one end the track passed under a concrete mixing plant with a 1-cu. yd. mixer and two 1-cu. yd. hoppers with air-operated discharge doors, arranged so that two skips could be filled simultaneously.

In placing the concrete on the upstream face, timber side and end forms 12 in. deep, incorporating the copper seals between the slabs, were laid (*Fig. 2*) and the vacuum was applied to the top shutters. These shutters were 20 ft. long

by 2 ft. wide, and consisted of a waterproof plywood face $\frac{1}{2}$ in. thick screwed to a frame of rolled-steel channel. Holes $1\frac{1}{2}$ in. diameter were bored through the plywood at 3-ft. centres along the length of the shutter, and a steel pipe, $1\frac{1}{2}$ in. diameter with flanged tee-pieces, inserted so that the tees coincided with the holes,

was connected to the back of the shutter. One end of this pipe was blanked off and a vacuum-gauge screwed into the plug; the other end was fitted with a quick-release coupling for attachment to the vacuum manifold. The space between the frame and the plywood was filled with concrete to increase the weight of the



Fig. 2.—Concreting Lower Part of Face.

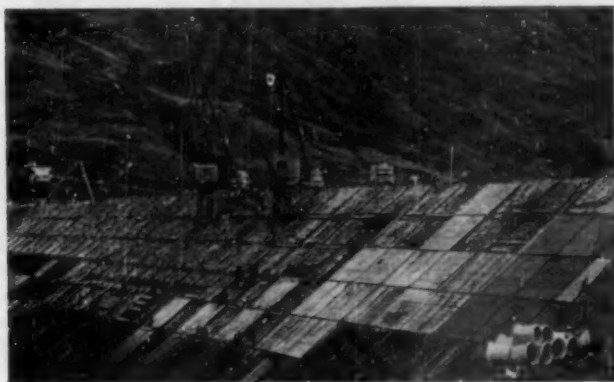


Fig. 3.—Casting Slabs on Upper Part of Face.

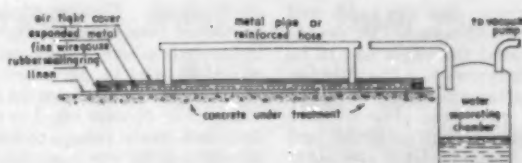


Fig. 4.—Arrangement of Vacuum Plant.

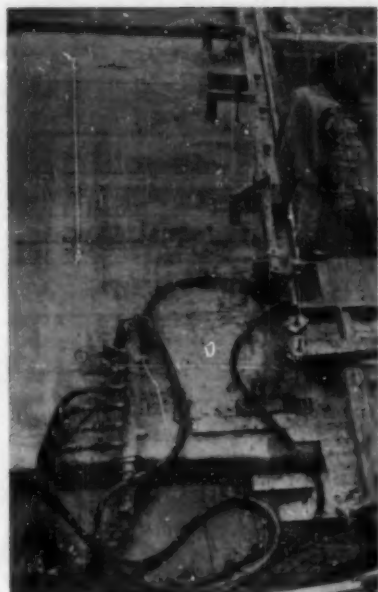


Fig. 5.—A Vacuum Shutter.

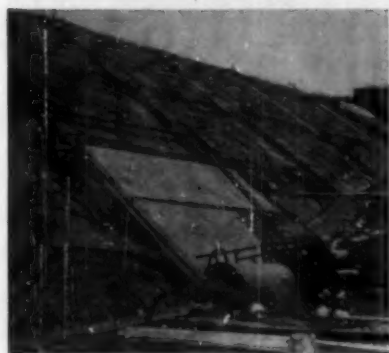


Fig. 6.—Vacuum Plant in Use.

December, 1936.

shutter and to seal the joints in the pipe, only the two ends of the pipe being left exposed. The principle of the construction of a vacuum shutter is shown in Fig. 4. Two lifting eyes were fitted so that when the shutter was lifted it hung at the same slope as the face of the dam.

The front face of the plywood was sealed round its edges by timber strips 2 in. wide by $\frac{1}{4}$ in. thick bedded in a bituminous material and nailed to the plywood. The small air-space required was formed by tacking a sheet of 16-gauge $\frac{1}{4}$ -in. steel mesh to the face and this was covered with gauze. Finally, unbleached linen was stretched across the face and tacked into position.

Four shutters were used on each slab. The procedure was to place a shutter at the bottom of the slab to be concreted, fill it with concrete, and apply the vacuum; the next shutter was then placed above the first and the operation repeated until all four shutters had been filled. By this time the first shutter could be lifted and placed above shutter No. 4 and concreting continued, and a slab could be concreted in 2 $\frac{1}{2}$ hours.

Vibration was used during the placing of the concrete and also for a short time after the vacuum had been applied; it was found that in addition to quickening the compaction of the concrete, the vibration helped to seal any small air leaks in the shutter. A vacuum reading of between 15 and 20 Hg at the shutter resulted in a satisfactory surface finish. Immediately after stripping the shutter the surface of the concrete was dry and dense, and generally it had no further treatment.

At the end of each day's work the shutters and the pipes were hosed. The linen covers were left in position unless they were to be renewed, in which case the cover was stripped off and the opportunity taken to clean the gauze and mesh. The average number of times a shutter was used before the linen had to be

renewed was twenty, and the mesh and gauze after about 180 uses. The timber sealing strips around the edges had to be replaced fairly frequently. The number of times each shutter was used during the work was about 750; the plywood face was still in good condition, and was used as shuttering on another part of the work.

During the second stage, eight shutters were made to enable two slabs to be concreted together. Four men were employed to each crane and were responsible for handling the shutters, placing the concrete, applying and timing the vacuum, and cleaning and maintaining the shutters; none of them had previous experience with this type of concrete, but after a short time became proficient.

The vacuum was applied by two rotary pumps with capacities of 348 cu. ft. per minute and 275 cu. ft. per minute and driven by 25-h.p. and 15-h.p. electric motors. During stage 1 the pumps were placed where they would need the least movement. During stage 2 two pumps were used near each end about halfway up the face and 700 ft. apart. They were linked together by a 3-in. screw-jointed main pipe with tees and valves about

80 ft. apart. Flexible pipes of 3 in. diameter led from these tees to the slab being concreted where a six-valve reduction manifold of 1½ in. diameter (Fig. 5) linked the shutters to the vacuum supply. Two tanks (Fig. 6) were fitted in the main pipeline close to the pumps to collect the water drawn out of the concrete. The pumps and pipeline gave very little trouble under normal conditions, but there was a great tendency for the water in the pipelines to freeze in cold weather; steam-heating the aggregate was helpful, and it was found to be important not to open the line to the atmosphere when the vacuum had been applied.

The rate of concreting varied considerably from month to month, due mainly to the weather; the best daily production was five 20-ft. by 20-ft. slabs by two teams of men in ten working hours, and the best monthly production by two teams was 99 slabs.

The consulting engineers were Sir William Halcrow & Partners, and the contractors Messrs. Richard Costain, Ltd. Millars Machinery Co., Ltd., are the licensees for the vacuum process in this country.

The Cost of Multiple-story Buildings.

MR. PETER DUNICAN writes as follows.

It is surprising that in your November, 1956, number Mr. W. E. J. Budgen should suggest that in your October number Mr. Ove Arup, C.B.E., was arguing the universal validity of cross-wall structures for high flats. Of course he was not. Neither did the report of the Building Research Station make any assumptions in the matter—they stated only the conclusions they reached after studying a number of widely differing schemes. Cross-wall structures are not necessarily economical in themselves, but generally it has been found by even the most perverse and undisciplined planners that cross-wall structures lead to economical flats, and it is this result that matters.

Mr. Budgen makes a number of detailed points, all of which were thoroughly investigated by the design team set up by the London County Council to carry

out the Picton Street development. The team consisted of architect, engineer, quantity surveyor, and contractor, and the definite conclusion they reached was that for this particular development, which consisted of four eleven-story blocks and sixteen four-story blocks, cross-wall structures in concrete produced the cheapest dwellings. It may well be that in some other schemes, with different planning requirements, a beam-and-column solution or a beam-column-and-wall structure may produce the best results. This is a matter for investigation in each particular case and is, in passing, a justification for considering the problem without prejudice. It would be a severe criticism of any planner if he allowed the structure to render his planning unsuitable for its purpose. In fact it would be a negation of planning.

Lightweight Aggregate from Pulverized-Fuel Ash.*

By W. KINNIBURGH, F.R.I.C.

PULVERIZED-FUEL ash is the residue from the combustion of powdered coal in modern boiler-furnaces used in many of the power-generating stations of this country. It is a grey powder resembling Portland cement in fineness and general appearance. Ash of this fineness is gas-borne, and is recovered from the flue-gas either by electrostatic precipitators or cyclone separators, from which it is obtained as a dry powder. The material consists of minute spherical glassy particles as shown in Fig. 1. These may be made to cohere by heat treatment producing porous pellets having considerable strength; an enlarged cross section of a pellet is shown in Fig. 2.

Many tons of material suitable for use as aggregate in concrete have been produced at the Building Research Station by the sintering of pulverized-fuel ash, and tests have been carried out on this aggregate and on the concrete produced from it. Most of the work done so far has been on concrete suitable for block-making, as it was known that in the first place, at any rate, the aggregate would be required for this purpose. Table 1 gives a few examples of the properties of "clinker-type" blocks made with this aggregate compared with blocks made with a typical furnace-clinker aggregate. It will

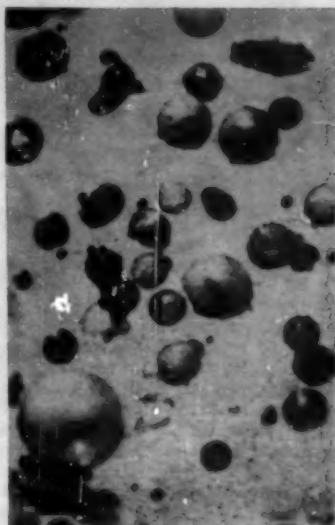


Fig. 1.—Photomicrograph of Ash.

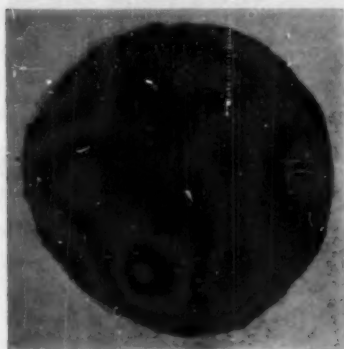


Fig. 2.—Enlarged Cross Section of a Pellet.

be seen that blocks made with pulverized-fuel ash aggregate are well within the requirements of the British Standard and have properties superior to the clinker blocks used in the tests. A small part of the aggregate was crushed in order to obtain the required grading.

Whilst most of the work has been done on concrete suitable for blocks, some attention has been paid to structural concrete made with this aggregate, and Table 2 shows typical results obtained with various mixtures of vibrated concrete. A compressive strength of about 2500 lb. per square inch at a dry density of about 95 lb. per cubic foot can be expected using this aggregate, whilst compressive strengths up to 3500 lb. per square inch or more can be attained by the inclusion of sand, but with some sacrifice in lightness.

Sintered pulverized-fuel ash, in common with other lightweight aggregates, can be used to advantage for purposes

* Crown Copyright Reserved.

TABLE 1. PROPERTIES OF CONCRETE BLOCKS MADE WITH PULVERIZED-FUEL ASH AND CLINKER.

Type of aggregate	Density of graded aggregate (lb. per cu. ft.)	Proportions cement : aggregate (by volume)	Compressive strength at 28 days (lb. per sq. in.)	Dry density of concrete (lb. per cu. ft.)	Drying shrinkage (per cent.)
P.-F. Ash No. 1 . . .	59.7	1 : 6	1000	76	0.047
P.-F. Ash No. 2 . . .	62.4	1 : 9	630	71	0.036
		1 : 6	1050	80	0.047
P.-F. Ash No. 3 . . .	60	1 : 9	630	71	0.035
Clinker (20% combustible content) . . .	60	1 : 9	720	72	0.027
B.S. No. 2028, Type B blocks	—	—	860 400	86 78	0.063 0.055
			Not less than 400	Not greater than 100	Not greater than 0.06

such as insulating concrete toppings on concrete roofs. Retention of water by lightweight aggregates frequently causes trouble if some of the mixing water becomes sealed between the base and the impervious top layer. These pellets have been treated with a bitumen solution to reduce the water absorption and such aggregate has been studied in the laboratory and on a roof. It has been found that the mixing water can be reduced to one-third of that normally used. *Fig. 3* shows a roof covering being laid.

No-fines concrete made with pulverized-fuel-ash pellets has a remarkably high degree of workability due to the spherical shape of the pellets (*Fig. 4*).

The production of pellets from extremely fine powder is done by sintering at high temperature to bring about the cohesion of the particles in a state of incipient fusion. The air for combustion is blown through a permeable bed of material.

The ash inevitably contains some unburnt fuel, and it would be of prime importance if this fuel were sufficient to raise the temperature of the ash to the

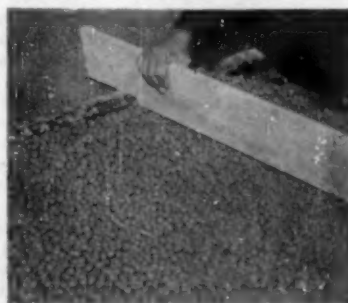


Fig. 3.—Levelling Concrete made with Pellets.

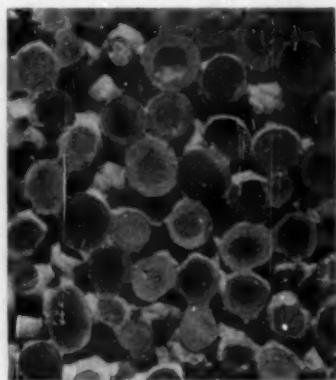


Fig. 4.—“No-fines” Concrete made with Pellets of Pulverized-fuel Ash.

TABLE 2. PROPERTIES OF VIBRATED STRUCTURAL CONCRETE

Proportions (by volume)	Water-cement ratio	Compressive strength (lb. per sq. in. at 28 days)	Dry density (lb. per cu. ft.)
1 : 6	1.40	1500	91.8
1 : 5	1.27	1850	93.7
1 : 4	1.02	2750	96.7

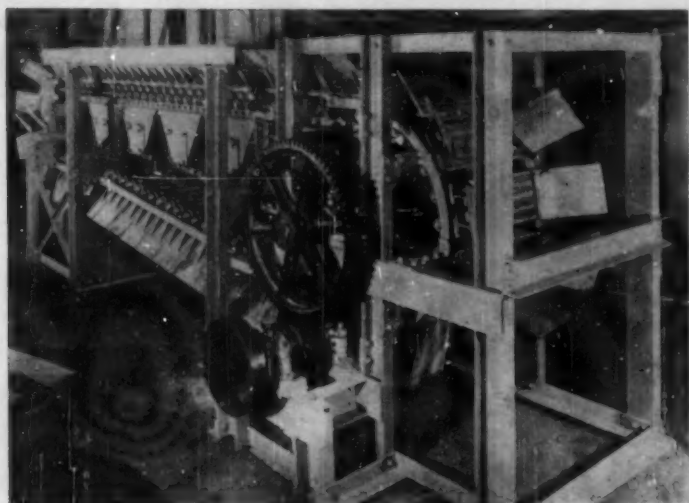


Fig. 5.—Pilot Sintering Strand.



Fig. 6.—Machining for Pelletizing Ash.

sintering point. Work done at the Building Research Station indicates that in a vertical shaft kiln (Fig. 7), in which there is good conservation of heat, ash with carbon content of about 3½ per cent. can be sintered without additional fuel; this is about the lowest of the range of fuel contents commonly met with in pulverized-fuel ash. On the other hand, it has been shown elsewhere that about 8 per cent. of fuel is necessary for sintering to take place on an open hearth, such as the sinter-strand shown in Fig. 5 (reproduced by courtesy of Huntington Heberlein & Co.); this value is in the upper region of fuel contents frequently encountered. It would seem that the choice between the shaft kiln and the open hearth depends on the prevailing fuel content of the ash but, however high the fuel content of an ash, the sinter-strand requires continuous ignition from an external source of fuel, which is not necessary with the vertical kiln. Moreover, the fuel content of the ash from a single source cannot be depended upon to remain consistently high enough for the ash to be used on a sinter strand for the period of years necessary for the amortization of this expensive plant, so that sooner or later it might become necessary to augment the natural fuel content of the ash by the addition of powdered coal.

In order to provide ash of sufficient permeability to permit the passage of combustion-air, it was considered necessary to convert the fine ash into pellets. This can readily be done in the rotating pan shown in Fig. 6. The inclined pan rotates slowly and the ash cascades down the sloping channel under a fine spray of water; uniformly spherical pellets are thus formed which are strong enough to withstand handling (a fairly wide range of size of pellet is possible on this machine). The pellets are fed to the shaft kiln, sinter-strand, or other furnace, where in a strong air current the integral fuel is employed to heat them to their sintering temperature (1000 deg. to 1200 deg. C.).

To summarize, it is possible to convert pulverized-fuel ash into a strong aggregate by pelleting without a binder (other than water) and sintering the "green" pellets by means of the residual fuel of the



Fig. 7.—Vertical Kiln for Sintering Ash.

ash. The process is therefore fundamentally a cheap one: the labour cost should not be high but the capital cost of the plant is likely to be considerable. Several manufacturers are already doing development work and one firm is erecting a plant to sinter the entire output of pulverized-fuel ash from one of the principal London power stations, so that this aggregate may be available in the near future. The contributions made to this development are part of the research programme of the Building Research Station, and this paper is published with the permission of the Director of Building Research.

Design Based on Loads Causing Failure.

EXAMPLES OF DESIGN.

THE following is an abstract of a paper entitled "Load-factor Design in Building Regulations: Future British Practice", presented by Dr. D. D. Matthews, M.A., M.Sc., D.Eng., to the symposium on "The Strength of Structures" held in London recently under the auspices of the Cement and Concrete Association.

Load-factor design is essentially the design of sections to carry "ultimate" loads, that is loads causing failure, equal to the design loads multiplied by a load factor. Load-factor design does not affect the determination of the moments and forces in continuous structures, which it is assumed will generally be calculated by the theory of elasticity. The method applies to the design of sections, not to external moments and forces.

In the elastic theory sections are so proportioned that when subjected to the design loads the stresses in the concrete and steel are specified safe fractions of their ultimate strengths. The difference between the two methods is due to the fact that the ratio of the design load to the ultimate load is not equal to the ratio of the design stress to the ultimate stress as computed by the elastic theory on the basis of a constant modular ratio. If these ratios were equal there would be no difference between the methods.

For under-reinforced sections, in which the ultimate strength is primarily determined by the reinforcement to resist tensile forces, the difference between the two methods is slight. For over-reinforced sections (which require reinforcement to resist compression as well as tension) there is a significant difference between the methods. This is due to the under-estimation of the compressive capacity of the concrete by the elastic method, which leads to the unnecessary use or over-provision of reinforcement to resist compression in sections subjected to bending only as well as those subjected to combined bending and compression. The practical advantage of load-factor design in normal building construction is the elimination or reduction of reinforcement to resist compression. The load-factor method applies only to the tensile stresses in reinforcement and the compressive stresses in reinforcement and concrete.

The extension of the method to shearing and bond stresses is not yet practicable.

The definition of load-factor design does not include the determination of the actions in continuous structures due to inelastic behaviour near ultimate loads. The investigation of the inelastic behaviour of reinforced concrete indeterminate structures has not reached the stage for inclusion in the Code of Practice. The terms "limit design" and "yield-line theory" have been used to distinguish this aspect of inelasticity from the concept of load-factor design.

The recent report of the Joint Committee of the American Society of Civil Engineers and the American Concrete Institute on load-factor methods uses the term "ultimate-strength design", which is also adopted in the current proposals for the revision of the Building Code of the American Concrete Institute. The main difference between these ultimate-strength design proposals and those proposed for the revised British Code of Practice No. 114 is that the British method proposes the adoption of different values of the load factor to be provided against failure of the steel and against crushing of the concrete instead of a single value for the two forms of failure.

If a section is designed for a load factor of 2 against a failure primarily due to yielding of the reinforcement and a load factor of 3 against failure due primarily to crushing of the concrete, then failure must occur at the lower load factor due to yielding of the reinforcement. The reason for specifying a higher load factor for crushing of the concrete is the extreme undesirability of this form of failure, coupled with a recognition of the great variability of the crushing strength of concrete. All sections designed according to the British proposals will fail primarily due to yielding of the steel provided that the concrete at the time of the test has two-thirds of its specified crushing strength. As this crushing strength is normally required at 28 days, the chance of failure due to crushing during the life of the structure is as remote as it is undesirable. The American proposals are restricted to members made with "controlled" concrete, whereas the proposals

for the revised British Code permit the use of load-factor design for all grades of concrete. This distinction justifies, at least in part, the less severe requirement against failure due to crushing of the concrete.

Rectangular Beams.

Rectangular sections commonly occur at the junctions of T-beams with columns, when the upper flange is in tension, and in beams crossing roof lights. The shape is ill suited to reinforced concrete, and the use of load-factor design is an advantage for this section, which serves as a convenient example for comparing the application of the two methods of design.

Consider a rectangular section designed for a modular ratio of 15 with stresses in the steel and concrete of 18,000 lb. and 1000 lb. per square inch respectively. The moment of resistance of both the steel and concrete is $193bd^2$ and the amount of reinforcement is 1.26 per cent. The calculation of the moment of resistance by the load-factor method starts by equating the force in the steel at its yield-point to the compression in the assumed rectangular "stress block".* The stress in the rectangular block when the steel is stressed to its yield-point is the cube strength multiplied by a factor (which has been determined experimentally to be $\frac{2}{3}$) relating the cube strength to the maximum attainable uniform compression in bending and multiplied again by the ratio of the load factors.

Thus the uniform compressive stress in the assumed rectangular "stress block" when the steel yields is

$$u \times \frac{2}{3} \times \frac{2}{3}$$

For a permissible stress of 1000 lb. per square inch, $u = 3000$ lb. per square inch, so

$$\frac{4u}{9} = 1333 \text{ lb. per square inch.}$$

The depth of the stress block is thus calculated, as a fraction of the effective depth, for a yield stress of 36,000 lb. per square inch, as

$$1.26 \text{ per cent.} \times \frac{18,000}{1333} = 0.341.$$

The moment of resistance of the concrete is then

$$0.341 \times 1333 \times (1 - 0.17) = 378bd^2$$

*See page 381.

for a load factor of 1 against yielding of the steel and $\frac{1}{3}$ against crushing of the concrete, or

$$MR_e = 189bd^2$$

for a load factor of 2 against yielding of the steel and 3 against crushing of the concrete, which is slightly less than the value of $193bd^2$ given by the modular-ratio method. The actual load factor against yielding of the steel at the working load permitted by the modular-ratio method is

$$\frac{378}{193} = 1.96,$$

which is slightly, if insignificantly, less than the ratio of the yield-point of the steel to the permissible stress of

$$\frac{36,000}{18,000} = 2.$$

The reinforcement required by the load-factor method for $193bd^2$ is 1.29 per cent. instead of 1.26 per cent.

The maximum moment of resistance of the concrete is determined in the load-factor method by assuming that the "stress block" extends half-way down the effective depth. For a load factor of 2 against yielding of the steel, the assumed uniform compressive stress is

$$\frac{1}{2} \times \frac{4}{9} \times u = 667 \text{ lb. per square inch,}$$

the lever arm is $0.75d$, and the area of the "stress block" is $0.5bd$, so that the maximum value of

$$MR_e = 0.75 \times 0.50 \times 667 = 250bd^2.$$

This increase in the capacity of the section requires more reinforcement to balance the increased compression. The reinforcement required is

$$\frac{250}{18,000 \times 0.75} = 1.85 \text{ per cent.}$$

instead of 1.26 per cent.

In order to resist a moment of $250bd^2$, compressive steel is required under the modular-ratio procedure, the amount depending on the depth at which the reinforcement is placed. If this depth is $0.1d$, the required amount of compressive steel is 0.58 per cent. The tensile steel required is 1.61 per cent., which is less than in the case of the load-factor design, namely 1.85 per cent. So the total steel required is $0.58 + 1.61 = 2.19$ per cent. for the modular-ratio method

and 1.85 per cent. for the load-factor method for identical concrete sections and moments. The extra reinforcement required by the modular-ratio method is 18 per cent.

When compressive steel is required with the load-factor method, the extra reinforcement in the modular-ratio method is even greater than in the previous case. For a bending moment of $350bd^2$ the compressive and tensile steel required in the modular-ratio method are 1.6 per cent. and 2.2 per cent. respectively, a total of 3.8 per cent. The corresponding amounts required in the load-factor design are 0.6 per cent. and 2.5 per cent., so that in this case the extra steel required by the modular-ratio method is 23 per cent. The modular-ratio design has an ultimate-load to design-load ratio of 1.76, even though the ratio of the yield stress in the steel to the design stress is still 2. The modular-ratio method in this case produces a 12 per cent. weaker section, even though it contains 23 per cent. more reinforcement, all of which is wasted in providing an unrealisable strength in the compressive zone.

The preceding calculations (for values of Q of 193, 250, and 350 with the qualities of steel and concrete in most common use) illustrate the general tendency of the modular-ratio method to provide too little steel in tension (because the lever arm at working loads tends to be greater than the lever arm at ultimate loads) and far too much steel in compression because of the restriction of the working stress to the stress in the surrounding concrete multiplied by a modular ratio. The resulting designs may be significantly if not seriously weak in tension and wastefully strong in compression.

T-sections.

Two types of T-section are commonly met with in practice, namely (1) T-beams cast integrally with floor and roof slabs and (2) sections used in ribbed and hollow-tile floor and roof slabs. The dimensions of the flanges of T-beams are determined by the load and the span of the slab, which very often result in a larger flange than is needed to resist the compression in the beam. In these cases the moment of resistance of the concrete is not a controlling factor, and the section is determined by the tensile moment of resistance of the reinforcement at the bottom of the

section. In elastic design it is normal in these circumstances to neglect the compression in the concrete in the rib and to assume that the centre of compression lies at the mid-depth of the slab. This practice gives an identical lever arm, and therefore an identical amount of reinforcement, with those required by the load-factor method.

In ribbed and hollow-tile slabs the depth of the flange is not generally determined by other considerations. In these floors a minimum depth of section and flange is frequently an important requirement. In load-factor design the average compression in the flange is $0.667c_b$ and is independent of the depth of the flange, whereas in elastic design the average

compression in the flange, when $\frac{t}{c_{bm}} = 1.2$, varies from $0.5c_b$ for a flange half the effective depth to $0.816c_b$ for a flange one-sixth of the effective depth. In the

second case, when $\frac{d}{d_s} = 6$, the comparative moments of resistance of the concrete section are $0.126c_bbd^3$ for elastic design and $0.102c_bbd^3$ for load-factor design. This comparison neglects the compression in the rib below the slab and above the neutral axis in the elastic design, and above half the depth of the rib in load-factor design.

For $\frac{b}{b_r} = 6$, which is typical of ribbed construction, and for $\frac{d}{d_s} = 6$, the comparative moments of resistance of the concrete section are $0.137c_bbd^3$ for elastic design and $0.127c_bbd^3$ for load-factor design when the compression in the rib is considered. It is thus far more important to consider the compression in the rib for thin T-sections in load-factor design than in elastic design.

In the somewhat thicker sections that are typical of hollow-tile construction, the load-factor method gives higher moments of resistance for the concrete section. For example, with

$$\frac{b}{b_r} = 4 \text{ and } \frac{d}{d_s} = 4, MR_c = 0.172c_bbd^3$$

for load-factor design against

$$0.169c_bbd^3$$

for elastic design when the compression of the rib is considered. The comparative

figures when the compression of the rib is neglected are

$$0.146cbd^2$$

for load-factor design and

$$0.161cbd^2$$

for elastic design, which again illustrates the importance of considering the compression of the rib in the load-factor method; in elastic design the compression of the rib is $4\frac{1}{2}$ per cent. of the total moment of resistance, whereas in the load-factor method the compression of the rib contributes 15 per cent. of the total moment of resistance.

Columns.

In the discussion of rectangular beams it was observed that two-thirds of the cube strength is the maximum attainable uniform compression in bending. A similar ratio of two-thirds is also considered to be the maximum attainable average stress in an axially-loaded column. The direct compression in the British Standard Code No. 114 of 1948 for this type of column is $0.76 \times \frac{1}{3}$ of the cube strength, so that the load factor against crushing of the concrete is

$$\frac{1}{3} \div (0.76 \times \frac{1}{3}) = 2.63,$$

which is the value proposed in the revised Code for axially and eccentrically-loaded columns.

The choice of a load factor of 2.63 against crushing of the concrete in columns, which is less than the value of 3 against crushing in beams, seems paradoxical if it is not appreciated that the lower load factor of 2 against yielding of the steel in beams always governs the ultimate strength. The load factor for the whole column when axially loaded depends on the amount of reinforcement; thus, for the minimum percentage of 0.8, a cube strength of concrete of 3000 lb. per square inch and a yield-point of steel of 36,000 lb. per square inch, the load factor is calculated as follows:

$$\frac{1 \times \frac{1}{3} \times 3000 + 0.008 \times 36,000}{1 \times 760 + 0.008 \times 18,000} = \frac{2288}{904} = 2.53.$$

For the normal maximum amount of reinforcement, namely, 4 per cent., the load factor for axial loads is 2.32. So, in all cases of axial loading, the load

factor of the section is greater than the load factor against yielding of the steel in beams.

The load factor for columns subjected to bending and compression depends on the eccentricity. For small eccentricities up to where failure is due to tension, the load factor decreases with increasing eccentricity from the value for an axially-loaded column (about 2.5) to the value against yielding of the steel (2). Above the eccentricity at which failure occurs by yielding of the tensile steel, the load factor remains constant at 2 up to the infinite eccentricity due to bending only.

In the treatment of beams, the load-factor method does not directly take account of the strains at ultimate loads. The restriction on the depth of the assumed rectangular "stress block" automatically prevents the assumption of incompatible strains with the steels in present use. It is not possible to avoid reference to the strains at ultimate loads in columns subjected to combined compression and bending. The new British Code proposals are that the assumed maximum concrete strain ϵ_u at ultimate eccentric loading of a column should not exceed one-third per cent. This enables the depth of the neutral axis to be calculated for the load and bending moment producing simultaneous crushing of the concrete and yielding of the steel. For example, if $f_y = 36,000$ lb. per square inch and $E_s = 30 \times 10^6$ lb. per square inch, then the corresponding strain yield $\epsilon_y = 0.12$ per cent. and the depth of the neutral axis is

$$\frac{\epsilon_u}{\epsilon_u + \epsilon_y} d = \frac{0.333}{0.453} d = 0.735d.$$

In order to calculate the position and magnitude of the resultant compression in the concrete, the characteristics of the assumed "stress block" are needed. The Code proposals imply that

(1) The resultant compression is equivalent to a rectangular stress block extending to the neutral axis with an average stress of

$$\frac{1}{3} u \times \text{load factor against yielding of the steel} \times 0.85$$

$$= \frac{1}{3} u \times \frac{2}{2.63} \times 0.85 = 0.431u.$$

(2) the depth of the resultant compression is 0.425 times the depth of the neutral axis.

The eccentric load which, when multiplied by the load factor (2) against yielding of the steel, produces yielding of the tensile and compressive reinforcement simultaneously with a concrete stress of 0.431*u*, may be termed the balancing eccentric load *P_b*.

Fig. 1 shows the relationships between the permissible load and the bending

moment about the centre-line of a symmetrically-reinforced column 17 in. square for the two methods of design. The relationship for each method is drawn for a low percentage of reinforcement (0.83) and a high percentage of reinforcement (4.13). In all four cases the area of the compressive reinforcement has not been deducted in the calculation of the compression in the concrete. This is, of course, not a strict interpretation of the modular-ratio theory; it is hoped that

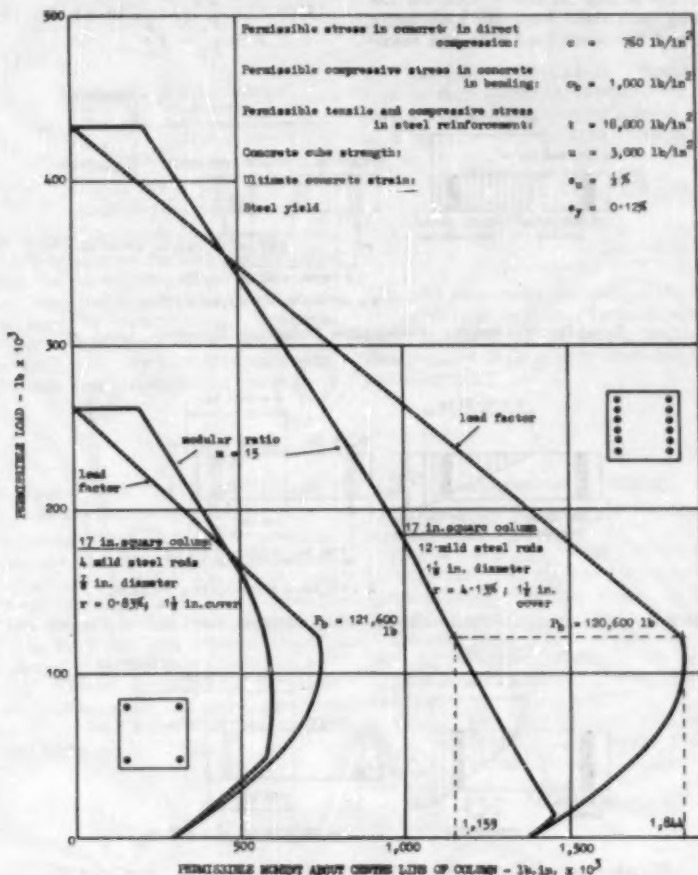


Fig. 1.—Relation Between Permissible Load and Bending Moment for Load-factor and Modular-ratio Methods of Design.

neglect of this over-meticulous refinement will be permitted in the load-factor clauses of the new Code.

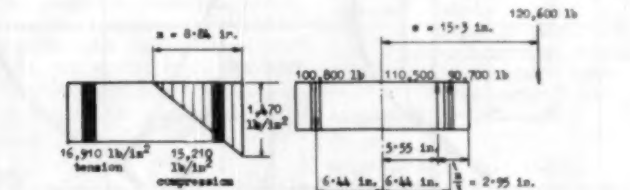
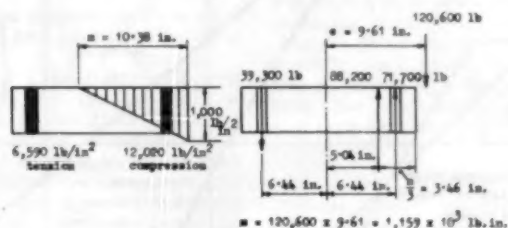
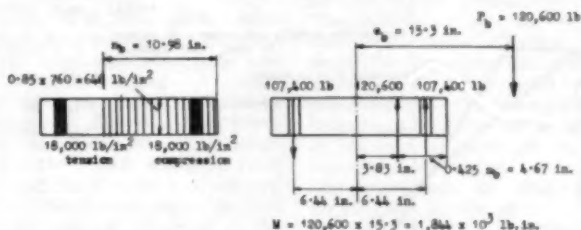
The difference between the design curves is less for a small amount of reinforcement than for a large amount because it is due to the underestimation in the modular-ratio method of the ultimate compressive capacity of the reinforcement as well as of the concrete. The essential difference in the results of the two methods of design is shown in Fig. 2, which gives the magnitude and positions of the resultant forces acting on the section for the balancing eccentric load in load-factor design and the same load with the maxi-

mum moment permitted by modular-ratio design.

The load-factor curves consist of an assumed straight line between the axial load P_o and the balancing eccentric load P_b . Although this line is in good agreement with experimental results, it must be emphasised that it is not based on theoretical analysis; such analysis leads to a cubic equation which is practically the chosen straight line.

The algebraic equation for the straight line is

$$P = \frac{P_o}{1 + \frac{F_o}{P_b} - 1 \frac{e}{e_b}}, \text{ in which}$$



REINFORCEMENT 4.13 PER CENT. COVER OF CONCRETE $1\frac{1}{2}$ IN.

Fig. 2.—Column 17-in. Square.

$$P_0 = cBD + tA_s$$

$$P_b = cBD \times 0.85n_b', \text{ and}$$

$$P_{be} = cBD^3 \left[0.85n_b' (0.5 - 0.425n_b') + 0.5rd_1' \left(\frac{t}{c} \right) \right],$$

where c is the permissible stress in concrete in direct compression,

t is the permissible stress in steel in tension and compression,

B is the breadth of the column,

D is the total depth of the column,

$$n_b' = \frac{\text{depth of neutral axis for } P_b}{D}$$

$$r = \frac{A_s}{BD}$$

$$= \frac{\text{total area of symmetrical reinforcement}}{BD}$$

$$d_1' = \frac{\text{distance between reinforcement } (d_1)}{\text{total depth of column } (D)}$$

This equation applies only to symmetrically-reinforced rectangular columns in which the permissible stress in the steel in tension is equal to the permissible stress in the steel in compression. Practical cases for other conditions are better treated arithmetically from first principles.

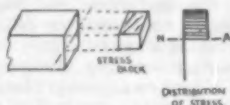
For loads less than P_b the curves are

derived from the conditions of equilibrium based on the characteristics of the "stress block" implied in the Code, and on the fact that the tensile and compressive steel both yield at ultimate loads for the whole range $P = P_b$ to $P = 0$. The resulting relation between P and e (the eccentricity about the centre-line of the column) is

$$P = cBD \left[(0.5 - e') + \sqrt{(0.5 - e')^2 + rd_1' \left(\frac{t}{c} \right)} \right],$$

$$\text{where } e' = \frac{e}{D}.$$

[The term "stress block" denotes the volume that would be obtained by multiplying the stress acting on a cross section of a member by the area over which it



acts and represents the compressive force acting at that section. In most ultimate-load methods of design a rectangular distribution of stress is assumed, as in the diagram.]

The Associated Portland Cement Manufacturers, Ltd.

SIR GEORGE EARLE, C.B.E., is relinquishing the Chairmanship of the Associated Portland Cement Co., Ltd., on 31 December, 1956, from which date he will be President of the Company. Mr. J. A. E. Reiss (the present Deputy Chairman) will be the new Chairman and Mr. V. C. Ellison (at present a Director) will be a Managing Director and also Chairman of the Cement Marketing Co., Ltd., in place of Mr. Reiss.

Lectures on Building.

ARRANGED by Ministry of Works. Admission free.

The R.I.B.A. Form of Contract. By D. Gardam. North Staffordshire Technical College, Caudon Place, Stoke-on-Trent. December 11. 7.15 p.m.

Flooring and Flooring Materials. By W. J. Warlow. College of Further Education, Newtown Road, Hereford. December 12. 7.15 p.m.

Mixing and Distribution of Concrete. By A. G. Stone. S.W. Essex Technical College, Forest Road, London, E.17. December 13. 7 p.m.

Construction of Dams in Scotland.

To provide 600,000 tons of aggregates for two dams—one at the outlet of Loch Cluanie and the other at the outlet of Loch Loyne—for the Glen Moriston hydro-electric scheme now nearing completion for the North of Scotland Hydro-electric Board, a granite quarry with a capacity of 200 tons an hour was opened at the site. A 25-in. primary gyratory crusher, a 4-ft. secondary gyratory crusher, and six double-rotor hammer-mills were installed. Rock blasted from the face was loaded by two 2-cu. yd. shovels into 4½-cu. yd. shuttle dumpers, which transported the rock a short distance to the crushing plant. The crushed rock passed through screens to storage bunkers, and thence by conveyor to the batching plant. The maximum size of aggregate was 3½ in. For the first time in this country Trief cement was used (as described in this journal for August 1954).

The storage at the batching plant (Fig. 1), which was near Cluanie dam where most of the concrete was required, consisted of a hexagonal bin of 200 cu. yd. capacity with six compartments for aggregates and a compartment to contain 50 tons of cement in the centre supplied

from two silos each of 100 tons capacity. Tilting-drum pneumatically-controlled mixers, two with a capacity of 2 cu. yd. and one of 1 cu. yd., were used; the 1-cu. yd. mixer supplied either the block-making plant or the dams as required.

Instead of using normal shuttering for the faces of the dams, patent precast blocks with a face area of about 25 sq. ft. formed a permanent shutter, as briefly mentioned in this journal for January 1955. Each block weighed between 2 and 3 tons. About 500 blocks were cast in a shed each week and kept under cover for 24 hours, after which they were stored out of doors for 28 days before being used. Steel moulds were used, and the blocks were cast on a vibrating table designed by the contractors. The blocks were fixed roughly in position by mobile cranes, then jacked to the correct batter, and wedged in position with precast concrete wedges. The concrete for the dam was placed directly behind the blocks. It is seen in Fig. 2 that the blocks have dovetailed projections on the inner face to key with the backing concrete and with each other.

For the construction of Cluanie dam,

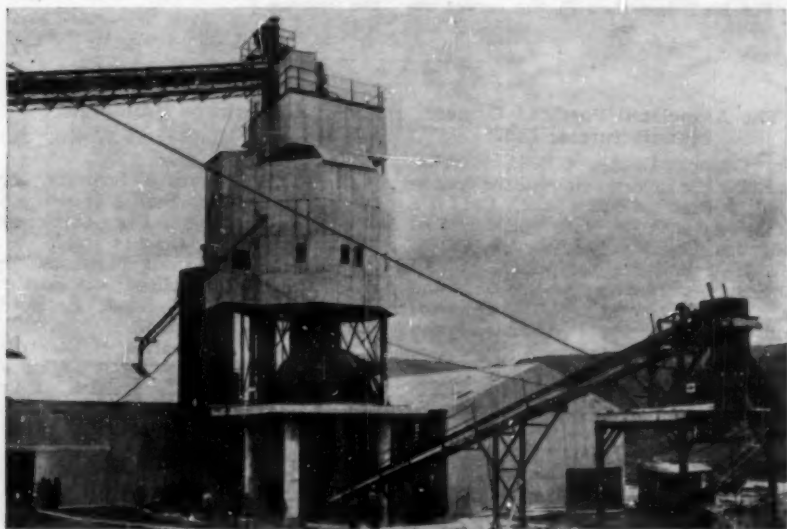


Fig. 1.—Mixing Plant, Aggregate Conveyor and Concrete Conveyor.

which is about 2300 ft. long, two electrically-operated luffing cableways (*Fig. 3*), each of 10 tons capacity, were used to transport the 210,000 cu. yd. of concrete, the facing blocks, and other materials. From the mixers concrete was delivered by conveyors to mobile hoppers which took it to the 4-cu. yd. skips which were carried by the cableways to the point of placing in the dam. The concrete plant had a capacity of 80 cu. yd. per hour. A return trip from the batching plant to the centre of the dam could be carried out in five minutes.

The cableways had a span of 2133 ft., the head and tail masts being 180 ft. and 160 ft. high respectively. The maximum depth of lift of the hook below the crest of the dam at the centre of the span was 300 ft., and the minimum height of lift of the hook above the crest was 44 ft. when fully luffed, the range of luff being 25 ft. on each side of the centre-line of the cableway. The "bounce" of the skip at the centre of the span when the concrete was discharged was about 15 ft. vertically. A 250-h.p. electric motor operating at 730 revolutions per minute gave a hoisting

speed of 250 ft. per minute and a travelling speed of 1000 ft. per minute.

Loyne dam, which is about 1800 ft. long and contains 60,000 cu. yd. of concrete, was constructed by a different method. Instead of using cableways, electrically-driven derrick cranes, two of 10 tons capacity and one of 5 tons capacity, with 120-ft. jibs were used. The cranes placed the precast blocks accurately in position in addition to placing the concrete. This dam is about four miles from the mixing plant, and concrete was transported to the dam in truck mixers of $4\frac{1}{2}$ cu. yd. capacity which deposited the concrete into 2-cu. yd. bottom-opening skips which were hoisted by the cranes. In this way about 25 cu. yd. per hour were placed.

For both dams the concrete mixtures used and the compressive strengths at 28 days were as follows. Precast blocks: 1:4; 3400 lb. per square inch. Upstream 4 ft. of dams: 1:4; 3400 lb. per square inch. Hearting: 1:7 (Trief cement); 1400 lb. per square inch.

The consulting engineers are Sir William Halcrow & Partners, and the Mitchell Construction Co. are the contractors.



Fig. 2.—Face-blocks in Position.

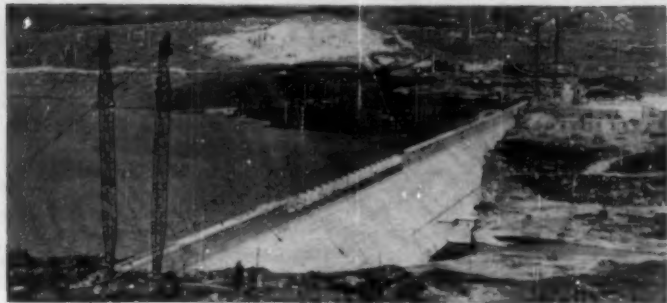


Fig. 3.—Cableway for Transporting Concrete.

Runways at Airfields.

THE following is abstracted from a paper presented on October 17 to a meeting of the Pavings Development Group of the Cement and Concrete Association by Mr. F. R. Martin, Superintending Civil Engineer of the Pavement Design, Experimental, and Development Branch, Directorate-General of Works, of the Air Ministry.

Riding Quality.

Concrete and good riding quality are rarely associated by the motorist or the aircraft pilot because many acres of roads and runways have been constructed without sufficient thought for the comfort of the user. While the need for relatively closely spaced joints in thin slabs is recognised, and random cracking through warping has been almost eliminated, little attention has been directed to riding quality at the joints. The aims have generally been quantity of output and test cubes with a high average compressive strength at twenty-eight days. Seldom has the aim been a smooth passage for the motorist or pilot. So far as aircraft with relatively low tyre pressures are concerned, it has not mattered a great deal. Quality of workmanship and pride in the finished article have been somewhat neglected, and it is not sur-

prising that bituminous surfaces are generally preferred. To-day, however, emphasis is being placed on surface tolerances to provide smooth surfaces; tolerances of $\frac{1}{4}$ in. variation in 10 ft. with q values of 30 in. per mile are the desirable limits for aircraft with tyre-pressures so high that they are virtually solid, and whose undercarriages need an even surface on which to land and take off.

The use of the scraping straight-edge has done more to produce good riding quality than any other item of equipment. The use of such a tool was introduced from the U.S.A.,* and with its use British contractors find that tolerances of $\frac{1}{4}$ in. in 10 ft. are possible. The straight-edge (*Fig. 1*) is 10 ft. long, having sufficient weight and rigidity to act as a cutting and smoothing tool while maintaining its shape. The straight-edge is placed on the slab at the near edge and, with the handle at knee height, is pushed to the far edge; the handle is then lifted to shoulder height and pulled to the near edge. The straight-edge is moved half its length along the slab and the process repeated. The surface of the concrete can hardly fail to have the specified surface tolerance.

* This tool was illustrated and described in this journal so far back as August, 1949.—Ed.



Fig. 1.—Use of Straight-edge.

Consistency of Concrete.

When the straight-edge is used the concrete must be fairly workable. There has therefore been a breakaway from the use of the stiff, lean, harsh mixtures that produced high cube strengths, but often left honeycombing in the slab and resisted a satisfactory surface finish. Let us see no more of the 1:8 and 1:9 mixtures with no slump. Let us rather use mixture of about 1:6 by weight, keep the water-cement ratio at about 0.5, and have mixtures sufficiently plastic to be brought correctly to level.

Joints.

Joints need no longer interfere with smooth riding, for after a joint has been



Fig. 2.—Cutting out Filler-board.

formed in the plastic concrete it can be filled to the surface with a board and the scraping straight-edge used to level the surface across it. The top few inches of the board can later be cut out to a depth of a few inches for sealing. With this method there is no need to form bull-noses on the edges of any but expansion joints which require to be sealed below the surface, or to disturb the concrete after the straight-edge has been used. Perhaps, too, a ban could be placed on the use of small trowels.

When limestone aggregate is used, sawn joints are generally economical and now commonly used. With igneous rock aggregate, and more so with flint-gravel,



Fig. 3.—Sealing with Hot Compound.

it is less likely that cutting, even if it does not produce a jagged edge, will be economical. Whatever the aggregate, all saw cuts should be made with saws having one or more diamond or silicon-carbide circular blades; they should be operated by engines of at least 25 b.h.p., and cooled during cutting with an abundant supply of cold water. The joints should be cut before any random cracking of the concrete occurs. It is difficult

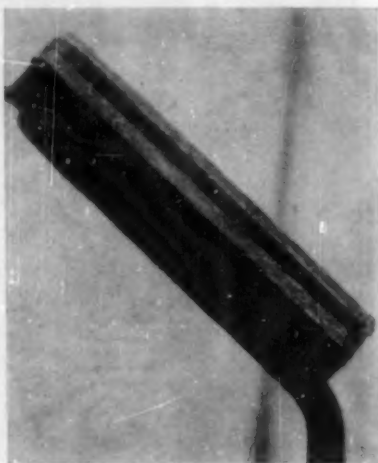


Fig. 4.—Hot Smoothing Tool.



Fig. 5.—Hot Smoothing Tool.

to judge the right time to cut with any but limestone aggregate, which is not so sensitive to temperature changes as is gravel; it may be any time between about eight hours and three days after laying. Random cracking probably always occurs to some extent, but it may be that some cracks can be accepted provided that they are not too numerous; this

view appears to be held in the U.S.A., where joint sawing is adopted much more than in this country.

For the sealing of joints two compounds have been used extensively, namely bitumen-rubber for slabs not subjected to jet fuel and pitch-rubber for areas subjected to jet fuel. None of the materials so far developed is entirely resistant to attack by heat and blast from jet engines. The problem has been overcome to some extent by finishing the seal below the top of the slab. Fig. 2 shows the method commonly used for cutting out the filler board where it extends to the top of a joint. Fig. 3 shows subsequent sealing with hot compound. A final ironing of the seal with a heated iron bar (Figs. 4 and 5) appears to give the best results. It is important that the material should not overflow on to the surface.

A method of sealing joints with strips of plastic material has been investigated and trial areas have been laid to test its

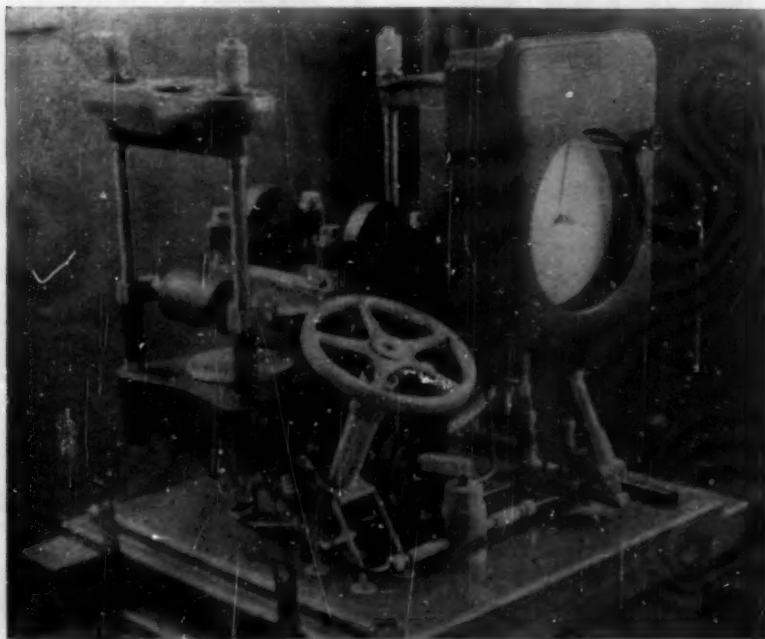


Fig. 6.—Portable Machine for Testing Beams.

RITECURE

membrane curing

**USED FOR CURING
OVER 28 MILLION
YARDS OF CONCRETE
IN THE BRITISH ISLES**

Ritecure produces an impervious film which provides controlled moisture retention throughout the curing period of 28 days.

Ritecure should be sprayed on the concrete immediately after finishing. Spraying is a one-man operation.

Ritecure is complete in itself, requiring no covering down or wetting. One coat only is required.

Ritecure. This can be supplied pigmented if required.

Write for our Technical Leaflets and Specifications

STUART B. DICKENS LIMITED

36 Victoria Street, London, S.W.1. Tel: Abbey 4890

Works: Old Milton Street, Leicester. Tel: Leicester 20090

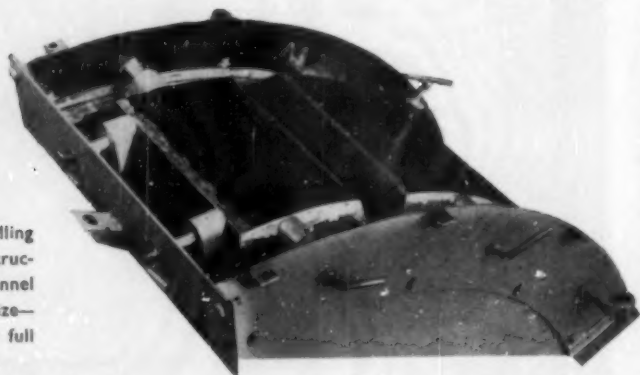
FOR TUNNEL CONTRACTS

**TRAVELLING
FORMS**

**SEGMENT
MOULDS**



USE STELMO EQUIPMENT
for continuous production and lower costs



If you require travelling forms for tunnel construction or moulds for tunnel segments to any size—write to us to-day for full details



*the most comprehensive
mould service in the world*

Please note new address :

STELMO LTD., 275 SHAKESPEARE ROAD, LONDON, S.E.24

Telephone : Brixton 4201

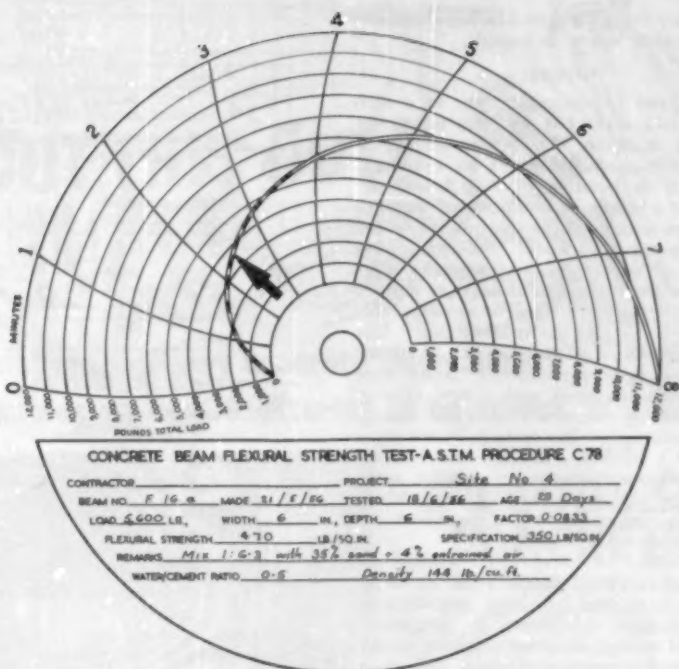


Fig. 7.—An "Automatic" Recording Chart.

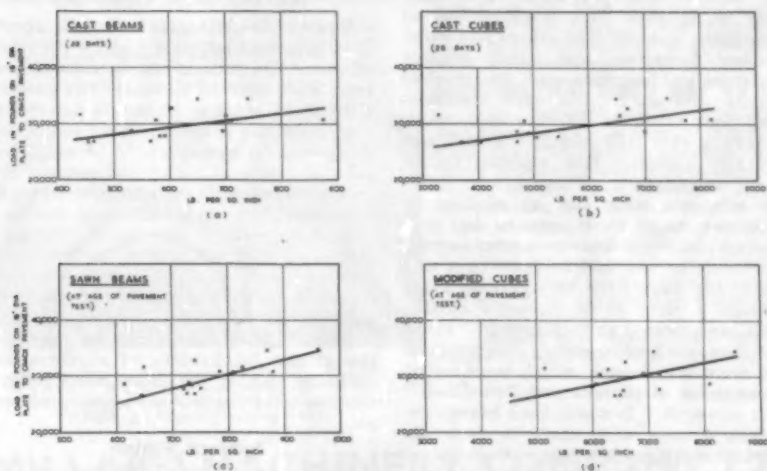


Fig. 8.—Effect of Bending Strength on Load-carrying Capacity.

efficiency in cold weather; a very uniform joint-sealing space is needed.

Strength.

Sufficient experience exists to design a concrete slab that will not fail under present or future known aircraft traffic.

Specifications require a minimum strength in bending of test beams instead of a minimum compressive strength of cubes as a guide to the quality of the concrete in the work. Six-inch cubes tested at seven and twenty-eight days have for long been the measure of quality and uniformity, yet designs are generally based on strength in bending. The logical measure of the strength of beams has now been introduced. Some sites have been equipped with a new type of beam-testing machine (Fig. 6) of American manufacture for testing beams on a span of 1 ft. 6 in. The machine is portable, and the strengths are recorded automatically on a chart (Fig. 7). What better record could an engineer wish for than a folder of these charts?

The effect of strength in bending on the load-carrying capacity of an 8-in. unreinforced slab has been investigated in a full-scale experiment by measuring the load needed to cause cracking of the corners of a number of slabs laid on a uniform base of Westergaard k (modulus of sub-grade reaction) of about 300 lb. per square inch per inch. The slabs were made with four combinations of aggregates, namely flint gravel and sand, crushed limestone and sand, crushed granite and sand. For each combination, four types of mixture were used, namely a rich stiff mixture, a rich wet mixture, a leaner stiff mixture and a leaner wet mixture. These sixteen different mixtures were laid at random to form two bays 20 ft. square for each mixture and eight free corners for testing. The concrete was laid in June 1955 and tested one year later by applying loads through a plate 18 in. diameter until a crack was formed at each corner. From each bay one broken corner was removed and sawn into beams, which were tested for modulus of rupture and "modified" cube strength. Beneath each corner removed, k tests were made to ascertain the uniformity of the base. Figs. 8 (a) to (d) give some of the results. It seems that although any of the samples gives

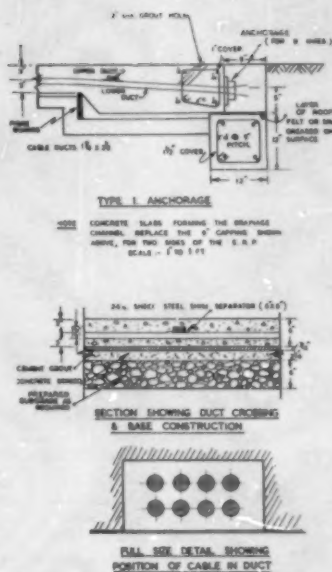


Fig. 9(a).—Prestressed Platform.

a good guide to the strength of the slab, the best guide is the bending strength of a beam sawn from the slab and tested at about the same age as the slab.

Air-entrained Concrete.

Some of the mixtures contained agents that entrained between 3 and 5 per cent. of air. The use of air-entrained concrete with internal vibration has enabled slabs 16 in. thick to be laid in one operation, with the advantage that joints can be spaced farther apart. The entrained air also aids workability and permits the production of concrete with good strength and durability. Air-entraining has also helped the change from harsh mixtures, and is another aid in the production of smooth and even runways. Mixtures require to be examined, and perhaps both the sand and water contents adjusted, so that full advantage can be taken of the greater workability of air-entrained concrete and at the same time reduce the loss of strength due to the entrained air.

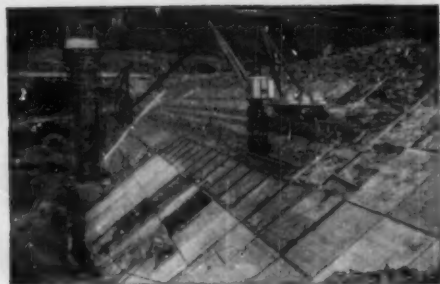
Surface Finish.

Much work remains to be done on the relationship between the wear of aircraft



CUT THIS OUT!

**Revolutionary (New) Concrete Development
enables vertical Shuttering to be struck in $\frac{1}{2}$ HOUR!**



Photograph by permission of The North of Scotland Hydro-Electric Board, Contractor: Richard Costain Ltd. Consulting Engineers: Sir William Halcrow & Partners. Contract: Garry Hydro Scheme, Quich Dam, Scotland. In situ cast facing slabs—surface processed.



Contractor: Sir Lindsay Parkinson & Co. Ltd. Consulting Engineers: J. D. & D. M. Watson, M.M.I.C.E. Contract: Filter tanks at Unstead Sewage Works for Borough of Godalming. External processing of walls.

MILLARS' VACUUM CONCRETE PROCESS

Concrete shuttering struck half-an-hour after pouring! Time-lag in curing cut by 75%! Take full advantage of the good weather to complete your concreting.

These are proved results of the Vacuum Process, for which Millars' Machinery Company Ltd. are the exclusive Licensees. Contracts carried out by firms such as Sir Lindsay Parkinson, John Laing, The Cementation Co. and Richard Costain show importance and value of the processes.

CONSTRUCTION TIMES CUT BY 70%

Even in midsummer, normal shuttering must remain in place for from 1-7 days, during which the rate of concreting is restricted by the number of shutters available. With the Vacuum Process, however, using a limited number of active shutters, this time is reduced to—from 1 hour to 2 days with a minimum increase in final concrete strength of 25%.

Nor is this all; for it has been found that curing precautions are no longer so necessary and there is no perceptible shrinkage at the construction joints.

Precast units may be lifted from their moulds within a few hours without handling steel by means of vacuum lifters.

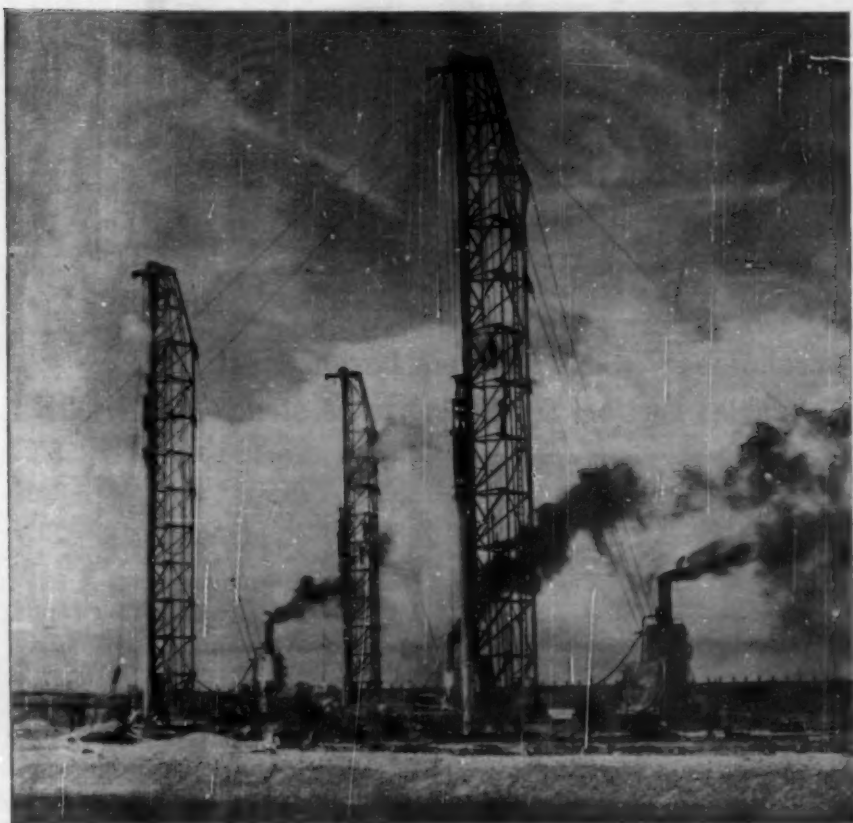
Further information will gladly be supplied.

MILLARS' MACHINERY COMPANY LTD.

PINNERS' HALL, GREAT WINCHESTER STREET, E.C.2
THORLEY WORKS, BISHOP'S STORTFORD, HERTS

• Telephone: London Wall 4266
• Telephone: Bishop's Stortford 694

Agents in AUSTRALIA, NEW ZEALAND, INDIA, BURMA, CEYLON, PAKISTAN, SINGAPORE, MALAYA, ADEN, ETHIOPIA



The VIBRO process is based on correct engineering principles and ensures the formation of piles of the precise length and size to suit the specified working loads.

The three Vibro plants shown above are forming 17" diameter piles varying from 60 to 70 feet in length, designed to carry working loads of 60 tons each.

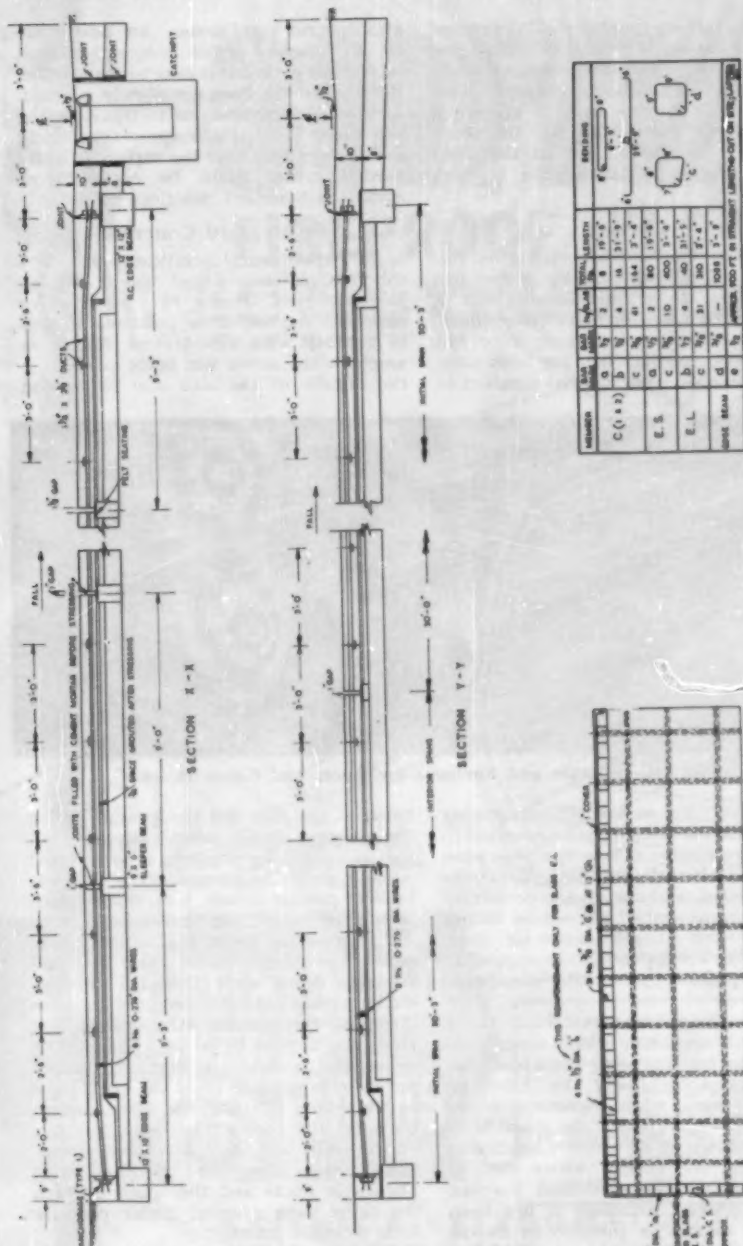


VIBRO

CAST-IN-PLACE
REINFORCED
CONCRETE PILES

THE BRITISH STEEL PILING COMPANY LIMITED

73, BATHURST LANE, LONDON, E.C. 4



DETAILS OF M.S. REINFORCEMENT FOR CORNER SLAB

Fig. 9(b).—Details of Prestressed Concrete Platform.

tyres and surface roughness. At present the riding surface is produced by dragging a stiff broom across the concrete while it is plastic. The effect, compared with the rise of a canvas belt, is to give a better surface in wet weather on which an aircraft can brake, and at the same time to produce a much more uniform surface.

Curing.

The need for efficient curing is important. Membrane curing alone has been found to be satisfactory over a large part of the year. At other times, particularly on very cold or very hot windy days, the slab has not been completely covered, and this has resulted in

atmospheric conditions. An advantage of an aluminised or white-pigmented membrane is that it is easy to see whether the surface has been completely covered. A power-driven machine to travel on the side-forms so that the spray completely and uniformly covers the surface is badly needed; this could be copied from American standard practice.

Prestressed Concrete.

An experimental jointless prestressed concrete platform about 200 ft. square has been laid during the past twelve months. Attempts to prestress a slab in contact with the ground results in much of the stress not being present in the middle of the slab due to friction

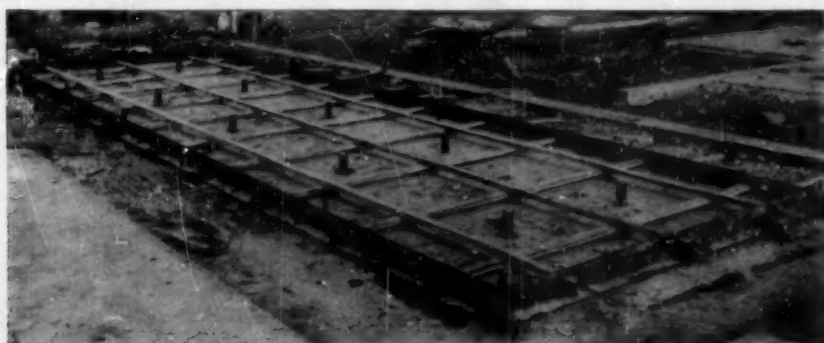


Fig. 10.—Shutter and Formers for Ducts and Grout Holes.

hair cracks. To ensure efficient curing at all times it is thought to be essential to apply a membrane curing spray as soon as possible after the finishing operations are completed, and also to use protective covers of whitewashed hessian on frames and keep the surface damp for some days; these covers should be applied as soon as possible after the membrane spraying.

Some experiments have been made with membranes into which aluminium powder or white pigments have been dispersed, following closely the American practice of using white pigmented membranes. Whether it will be possible to dispense entirely in all weather conditions with protective covers where highly-reflective membranes are used has not yet been proved, although it has been suggested that it is possible in humid

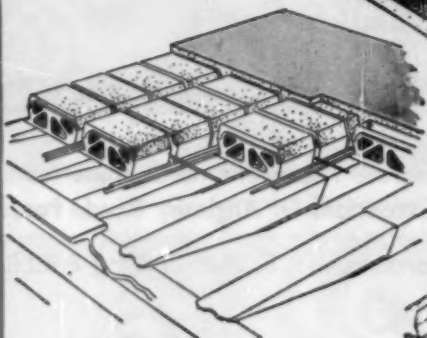
between the slab and the ground during the process. In the scheme shown [Figs. 9(a) and 9(b)] the concrete is prestressed while it is off the ground. The slab was built of precast panels, 6 in. thick, which were lifted by vacuum suction-pads on to walls projecting about $\frac{1}{4}$ in. above a prepared base (Figs. 10 to 13). The prestressing wires were threaded through ducts formed at 3 ft. centres in both directions through the slabs and the prestress was applied by jacks. The method of wedging is shown in Fig. 14. Special panels were made to resist the extra force at the edges. During the tensioning of the steel the panels were able to move on the walls to ensure an even distribution of stress throughout the whole area. The cable ducts and the space beneath the slabs were grouted under pressure with colloidal grout.



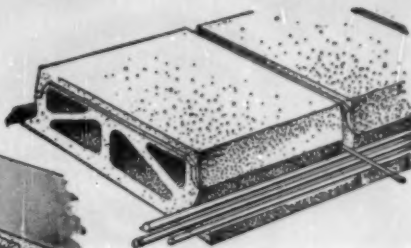
SMITH'S

FIREPROOF FLOORS

- The most adaptable System of Suspended Hollow Concrete Floor and Roof Construction for large and small spans. •



Showing Two-Way Reinforcement and Hollow Concrete Blocks laid on Trianco Telescopic Centers.



Smith's Two-Way Reinforced Floor for distribution of point loads with efficiency and economy.



Illustrating the continuous Soffit with natural Key to which plaster readily adheres without hacking or other preparation to form finished ceiling.

**2 WAY REINFORCED
SUSPENDED
CONCRETE FLOORS**

Midland Associated Company & Licensees

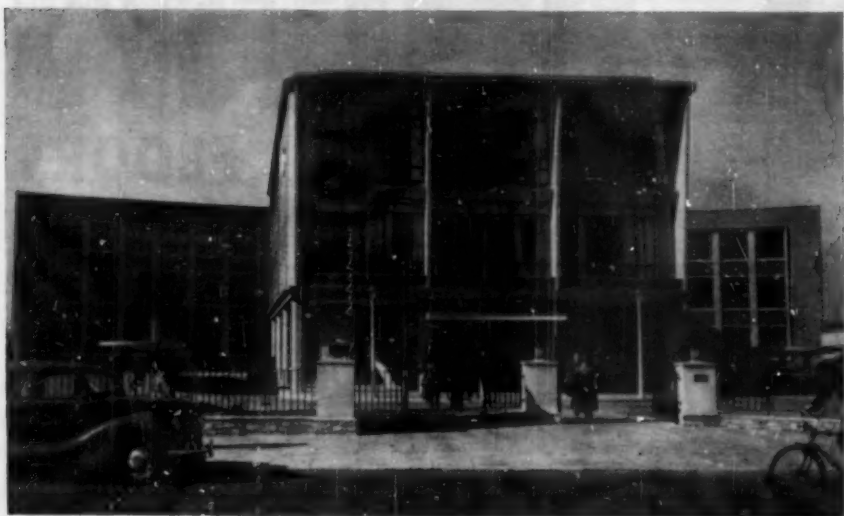
PARKFIELD CONCRETE PRODUCTS COMPANY LIMITED

St. Peter's Road
NETHERTON, Nr. DUDLEY
WORCS.

'PHONE : DUDLEY 4315

SMITH'S FIREPROOF FLOORS LTD
IMBER COURT • EAST MOLESEY • SURREY

EMBerbrook 3300 (4lines)



333 Simplex Cast-in-situ Concrete Piles were used in the foundations of the Municipal College Extensions in Anglesey Road, Portsmouth

Architect to the City of Portsmouth: F. Mellor, Esq., F.R.I.B.A.

Write for Illustrated Brochure

SIMPLEX CONCRETE PILES LTD.

25 BRECHIN PLACE,

SOUTH KENSINGTON,

LONDON, S.W.7

Telephone: Framantle 0035-6

The slab has not yet been tested but, with a prestress of about 250 lb. per square inch and a bending strength of 600 to 800 lb. per square inch, it is expected that it will resist an unlimited number of applications of loads of at least 50,000 lb. on a plate of 12 in. diameter.

In the course of this work it was found that the vacuum process resulted in variations in thickness of slabs, due to some extent to variable amounts of water removed and also to the movement of

the pad on the surface when the suction was released; to overcome this it will be necessary to dispense with the vacuum process or to cast the slabs vertically.

The rectangular ducts required rectangular wire spacers and caused difficulties in the threading of the wires; this will be overcome by using ducts of circular section. The threading of the wires in the ducts disturbed the metal "shim" plates fixed between the duct formers where they crossed each other, and grout escaped in a few places from

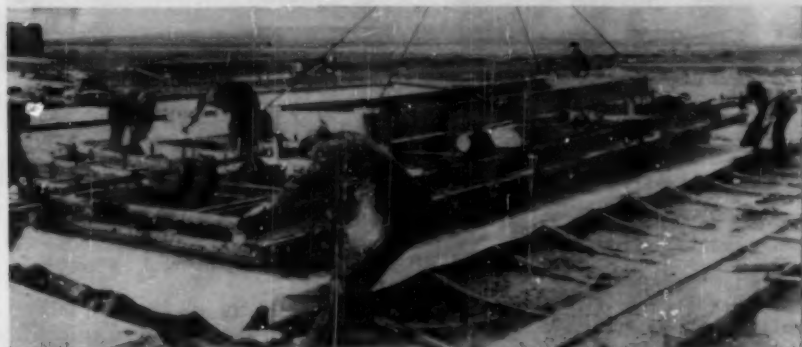


Fig. 11.—Lowering Suction-pad into Position.

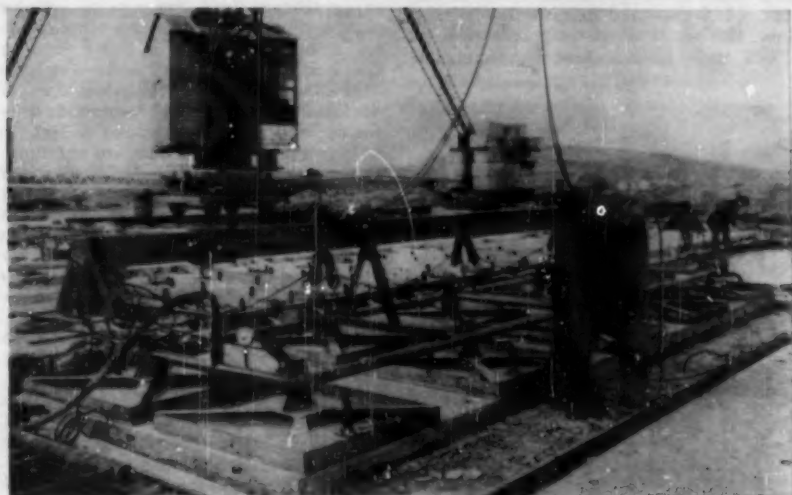


Fig. 12.—Suction-pads in Place ready for Lifting Slab.

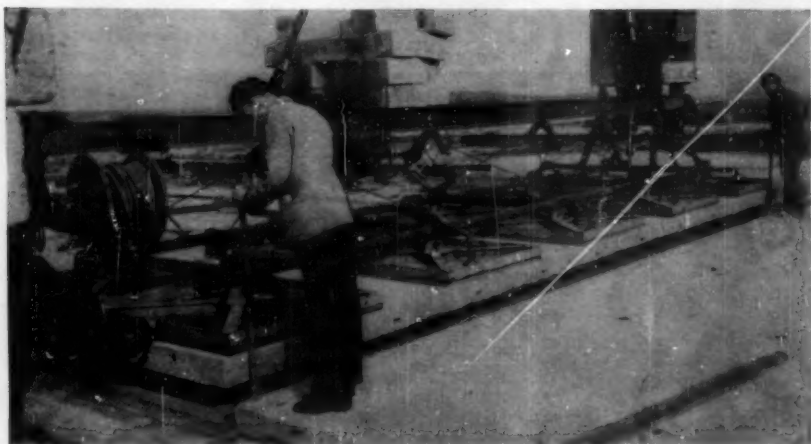


Fig. 13.—Lowering Slab on to Walls.

one duct to another; the use of circular ducts should avoid this trouble.

The main objects of the experiment were to see whether the idea of prestressing a slab while it was off the ground could be used in practice and, secondly, whether a slab so constructed would be as strong as was calculated and would maintain its strength at all times of the year. It is expected that, for heavy-duty slabs, the high cost of the process will be off-set to a large extent by saving in

excavation, in joints, and in quantities of materials. It is unlikely, however, that it will be economical for roads.

Testing.

Generally it has been accepted that an unreinforced slab fails when it cracks. Failure has been measured by applying an increasing load through a circular plate until a crack is formed; by applying a factor to the breaking load, a safe working load is assessed. For prestressed concrete, and probably also for reinforced concrete, this method does not apply, for simple cracking of slabs is no longer necessarily a measure of failure. The permanent movement of the surface runways under repeated application of the working load would seem to be the best measure of performance, and it may be that for unreinforced slabs also repeated loading within the assessed capacity, and the effects of fatigue, may be more damaging than has been thought. A programme of testing of unreinforced runways by repeated loading has therefore been arranged and will include prestressed and reinforced slabs. The strength will be assessed from the load that can be carried, say, 1000, 10,000 or 40,000 times, with a fixed maximum deflection or a permissible permanent settlement while still maintaining the riding quality of the surface.

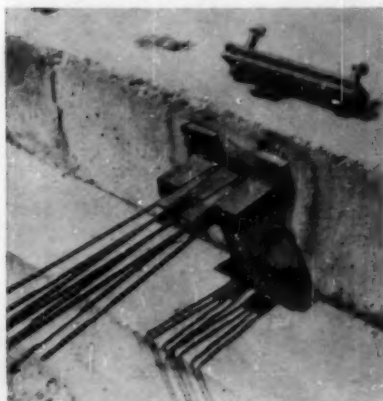


Fig. 14.—Method of Wedging Wires.

STERNSON

CONCRETE WATERPROOFERS

CONCRETE WATERPROOFING

MATERIALS

ACCELERATORS

FLOOR HARDENERS

BONDING MATERIALS, ETC.

Sternson No. 300	Waterproofing Admixture for Concrete and Mortar.
Sternson No. 310	Concrete Accelerator, Hardener and Dustproof.
Sternson No. 340	Concrete Accelerator, Hardener and Dustproof.
Sternson No. 355	To Rapid-Set Cement for Waterproofing Operations
Sternson No. 600	Metallic Jointing Material for Concrete or Brick.
Sternson No. 610	Metallic Bonding Between Old and New Concrete.
Sternson No. 620	Metallic Hardener for Heavy Duty Concrete Floors.

Other Materials include:

WETTING AGENTS

MASTIC IRON

PLAIN AND COLOURED

WAX POLISHES, ETC.

Write for our Technical Leaflets and Specifications

STUART B. DICKENS LIMITED

36 Victoria Street, London, S.W.1. Telephone: Abbey 4000
Works: Old Milton Street, Leicester. Telephone: Leicester 20390

LENSCRETE

GLASS AND FERRO-CONCRETE

for

SHELL ROOF

CONSTRUCTION

LENSCRETE LTD.

66 QUEEN'S CIRCUS

LONDON, S.W.8

TELEPHONE : MACAULAY 1063



Agents in all parts
of the British Isles,
Dominions and Colonies.

"CONSTRUCTION WITH MOVING FORMS"

By L. E. HUNTER, M.Sc., A.M.Inst.C.E.

72 pages. 53 illustrations.

Price 7s. 6d. by post 8s. 1.75 dollars in Canada and U.S.A.

Describes and illustrates practical methods of rapid construction with continuously-moving, or sliding, forms. This book will be of assistance to those familiar with the process, and will prevent mistakes being made by those using moving forms for the first time.

PRINCIPAL CONTENTS

- Construction of wooden and steel forms, yokes, and jacks.
- Details of deck, scaffolds, dragging at corners, circular and polygonal bins, and lateral bracing.
- Procedure of construction : Preliminaries. Levelling. Roof. Dismantling.
- Materials. Plant. Reinforcement. Construction in cold weather. Emergency equipment. Labour.
- Reinforcement : Design. Stacking. Cover. Bar schedules.
- Special applications : Structures of variable shape. Structures with floors. Structures without columns. Openings in walls. Tanks. Chimneys. Cost.
- Shutters Travelling Horizontally : For sea walls, culverts, and sewers.
- Hints and Reminders.

CONCRETE PUBLICATIONS LIMITED

14 Dartmouth Street, London, S.W.1, England



IN ROOFS, WALLS, FLOORS, STAIRS

You get
greater strength
with less cement
when you use

WIREWELD

REINFORCEMENT

WIREWELD reinforcement is a high tensile steel fabric, manufactured from Cold Drawn steel wire, electrically welded at all intersections, to B.S. 1221, Part A. Made in square mesh and oblong mesh, it gives maximum strength with a minimum of metal.

WIREWELD reinforcing fabric in the floors means less thickness of the floors and greater loads on the floors. With greater flexibility of planning and more space for use, WIREWELD represents both an initial and cumulative economy.

A PRODUCT OF TWISTEEL REINFORCEMENT LTD.

LONDON: 43 UPPER GROSVENOR STREET, W.1 (GROSVENOR 1216) **BIRMINGHAM:** ALMA STREET, SMETHWICK, 40 (SMETHWICK 1951)
MANCHESTER: 7 OXFORD ROAD, MANCHESTER, 1 (ARDWICK 1691) **GLASGOW:** 30 FINKYTON ROAD, GLASGOW, C.4 (BEL 2444)

MISCELLANEOUS ADVERTISEMENTS.

Situations Wanted, 4d. a word: minimum, 7s. 6d. Situations Vacant, 5d. a word: minimum, 10s. Other miscellaneous advertisements, 5d. a word: 10s. minimum. Displayed advertisements 3s. per column inch. Box number 1s. extra.

Advertisements must reach this office by the 23rd of the month preceding publication.

SITUATIONS VACANT.

SITUATION VACANT. Detailer-draftsman required for varied reinforced concrete work in sub-contractors' head office opposite Euston Station. Permanent, progressive, and superannuated post. Five-days' week. Telephone for appointment. EUS. (London) 4096.

SITUATION VACANT. Estimator required for reinforced concrete light frame structures, hollow tile floors, etc. Five-days' week. Pension scheme. Apply in writing, giving brief details of experience and salary required, to THE HELICAL BAR & ENGINEERING CO. LTD., 82 Victoria Street, London, S.W.1.

SITUATIONS VACANT. Experienced reinforced concrete detailers required for interesting and varied work with a large firm of building and civil engineering contractors. 5½-days' week. Canteen facilities. Apply, giving full details of experience, age, and salary required, to BOX 4324, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Civil engineering draughtsman required for work in London office of large civil engineering contractors. Work of varied nature, with scope for initiative and advancement. Commencing salary £600-£800 depending on experience. Five-days' week and luncheon vouchers. Pension scheme operates. Box 4228, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Senior reinforced concrete designers wanted by leading reinforced concrete engineers and contractors. Must be fully conversant with Code of Practice, L.C.C. Bye-Laws, and able to design light-framed structures from estimating stage to final details. Five-days' week. Pension scheme. Progressive position. Starting salary from £900 upwards according to ability. This year's holiday arrangements honoured. Juniors also required, similar conditions. Write Box 4172, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. Assistant structural engineers required with experience of reinforced concrete design. Experience of precast techniques advantageous. Salary according to experience and qualifications. Apply in writing to TECHNICAL MANAGER, THE SCOTTISH CONSTRUCTION CO., LTD., Sighthill Industrial Estate, Edinburgh.

SITUATIONS VACANT. Consulting structural engineers in new modern offices conveniently situated in Central Liverpool have vacancies for reinforced concrete and structural steel designer-detailers, in the salary range of £600-£800 per annum. Special opportunities exist for those interested in nuclear energy projects, and appointments in this field carry additional increments in salary. Positions offered are permanent with excellent prospects. Staff bonus and superannuation schemes are in operation. Apply in confidence, giving age and full details of experience, to BOX 4321, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATIONS VACANT. R. L. Bourqui & Partners require experienced designers and detailers immediately. Designers must be fully conversant with Code of Practice and L.C.C. Bye-laws, and able to design framed structures from estimating stage to final details. Knowledge of design of industrial structures also an advantage. Detailers to be first-class draughtsmen with good printing and line work, able to construct general arrangement drawings and details from designers' calculations. Holiday arrangements honoured. Good salaries offered to conscientious and competent men. Junior draughtsmen also required. Telephone Elmbridge 0439 for appointment.

LONDON COUNTY COUNCIL

ARCHITECT'S DEPARTMENT

Vacancies for Engineering Assistants (up to (818) and Engineer Grade III (up to (597) in the Structural Engineering Division. Work includes steelwork and reinforced concrete design and detailing for Council's buildings. Particulars and application forms from ARCHITECT (AR/EK/SE/3), The County Hall, London, S.E.1. (1278.)

SITUATIONS VACANT. The Glasgow office of 'TWISTEL' REINFORCEMENT, LTD., require reinforced concrete designers and detailers. Write, stating age and experience, to the CHIEF ENGINEER at 30 Pinkston Road, Glasgow, C.4.

SITUATION VACANT. Senior designer required by engineers who specialise in prestressing consulting work. Applicants must be 10 years out of degree and have had wide experience in a design office working on reinforced and prestressed concrete in a responsible position. Thorough knowledge of methods of analysis of structures and fundamentals of design essential. Preference will be given to applicants with some prestressing research experience and sufficient site experience for A.M.I.C.E. Write, giving qualifications, experience and present salary, to THE PRE-STRESSED CONCRETE CO. LTD., 171 Victoria Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete designer-detailer required for civil engineering contractors' drawing office. Experienced man wanted. Five-days' week. Luncheon vouchers. Apply in writing, stating experience, age, and salary required, to THE DEMOLITION & CONSTRUCTION CO. LTD., 3 St. James's Square, London, S.W.1.

SITUATIONS VACANT. Designers and detailers for reinforced concrete and structural steelwork in civil engineering department of THE COFFEE CO. (G.B.), LTD., 140 Piccadilly, London, W.1. Wide variety of structures for colliery and chemical and engineering, etc. Rudimentary knowledge of general building and drainage useful. Five-days' week. Staff pension scheme. Write stating age, experience, and salary required.

SITUATIONS VACANT. Reinforced concrete designers and detailers interested in widening their experience should apply to OVE ARUP & PARTNERS, 8 Fitzroy Street, London, W.1. Telephone: Langham 7781.

Opportunity for Reinforced Concrete Designers...

to join the staff of

BRC

There are vacancies for Reinforced Concrete Designers and Detailers at our Head Office and at most of our Design Offices in

LONDON · BRISTOL · LEEDS · LIVERPOOL
NEWCASTLE · GLASGOW · DUBLIN

We also have a few openings for Student Apprentices of good educational standard and for Students who have just completed the Higher National Certificate Course.

**THE BRITISH REINFORCED CONCRETE
ENGINEERING CO. LTD., STAFFORD**

Chief Engineer:
A. P. MASON, B.Sc., M.I.C.E., M.I.Struct.E., M.ASCE

SITUATIONS VACANT. Assistant engineers (structural) required by consulting engineers in their Nigeria office for road and bridge works. Age about 20 to 30. 15 months' tour with three months' paid leave, free furnished accommodation, and passage to and from Nigeria. Good salaries paid, depending on experience. Permanent position after first tour either Nigeria or United Kingdom. Good prospects for self-reliant men. Also assistant engineer experienced in water supply for small townships, required for design and administration work in the same area and on the same conditions. Apply R. TRAVERS MORGAN & PARTNERS, 11 Victoria Street, London, S.W.1.

SITUATION VACANT. Assistant to resident engineer required at once for reinforced concrete viaduct in London area. Must have some previous site experience and should preferably have passed Parts I and II of the A.M.I.C.E. examination. Salary: £700 per annum. Apply HOWARD HUMPHREYS & SONS, Consulting Engineers, Victoria Station House, Victoria Street, London, S.W.1. Please quote reference 364.

SITUATION VACANT. Structural engineer required by London consulting engineers for concrete design department. Applicants must have first-class Honours degree and at least 10 years' experience in the design of reinforced concrete and prestressed structures. Detailed knowledge of higher mathematics, of the design of indeterminate structures and the latest methods of design essential. Salary commensurate with responsibilities attached to the post. Apply in writing, with full particulars of age, qualifications and experience, to Box No. 551, c/o CHARLES BARKER & SONS, LTD., Gateway House, London, E.C.4.

SITUATIONS VACANT. Senior and junior draughtsmen required by London consulting engineers. Applicants should be good draughtsmen with considerable experience in reinforced concrete work. 5-days' week. Superannuation scheme. Luncheon and sports clubs. Reply by letter, with full particulars of age and experience, to Box No. 550, c/o CHARLES BARKER & SONS, LTD., Gateway House, London, E.C.4.

SITUATION VACANT. Structural engineering representative required for the North of England. Applicants should be age 35 upwards and must be Corporate Members of the Institution of either Civil or Structural Engineers. Applicants must have extensive experience in travelling and relationship with important building clients and architects for large structural works. Salary will be not less than £2000 per annum, according to experience and status of applicant. Applications, which should give fullest possible details, will be treated in absolutely strict confidence, and should be addressed to Box No. 65, c/o HOLMES SON AND POTT, Solicitors, 3 London Wall Buildings, London, E.C.3.

T. C. JONES & COMPANY LIMITED CONSTRUCTIONAL ENGINEERS

offer interesting careers with good salaries and congenial conditions in the following grades:—

1. Experienced Reinforced Concrete Designers.
2. Reinforced Concrete Draughtsmen.
3. Senior Structural Steelwork Designers, experienced in modern welding construction.

Our present volume of business and continuing expansion offer good prospects to suitable applicants. Five-days' week. Pension Scheme, etc. Please apply in writing to T. C. JONES & CO. LTD., Pier Head Chambers, Bute Street, Cardiff. Enclose envelope "Technical Staff".

LONDON COUNTY COUNCIL ARCHITECT'S DEPARTMENT

Vacancies for STRUCTURAL ENGINEERS in the DISTRICT SURVEYORS' SERVICE. Duties include checking of calculations and/or supervision of works in progress. Structural knowledge essential. GRADE II (salary on scale £987 to £1184), GRADE IIIS (up to £987), and ASSISTANTS (up to £818), with starting rates according to qualifications and experience.

Particulars and application forms obtainable from THE ARCHITECT (AR/EK/DS/5), County Hall, S.E.1. (3082.)

PORT OF LONDON AUTHORITY

The Port of London Authority have vacancies in their Drawing Office at Head Office, Trinity Square, E.C.3, for TECHNICAL ASSISTANTS of various grades, in the salary range of £645 to £956 per annum, for structural engineering designers and draftsmen.

Minimum qualifications are the holding of the Ordinary National Certificate in appropriate subjects and at least 3 years' experience in a design drawing office. Higher National Certificate is required for the higher grades. Experience in the design and detailing of reinforced concrete is essential, but knowledge of steelwork design will be an advantage.

It is the Authority's policy to encourage Technical Assistants to study for higher qualifications and facilities are provided accordingly.

Applications, giving age, qualifications and full details of experience, should be addressed to the ESTABLISHMENT OFFICER, Port of London Authority, Trinity Square, E.C.3.

SITUATIONS VACANT. Draughtsmen. Several vacancies exist for good intermediate and junior draughtsmen in precast reinforced concrete design office. Time off for technical school if required, and training given to juniors. Good salaries and prospects of advancement. Luncheon vouchers. Apply to MANAGING DIRECTOR, R. E. EAGAN, LTD., 167 Victoria Street, London, S.W.1.

SITUATION VACANT. Assistant engineer required by leading precast concrete manufacturers. Experience of reinforced concrete essential. Progressive position. Pension scheme. Five-days' week. Box 4400, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete designer for work in Victoria Street, London. Five-days' week, non-contributory pensions scheme after three years' service. Progressive position. Five years or more experience with reinforced concrete specialists preferred. Write, giving full particulars, to THE SPENCER WIRE CO. (DEVELOPMENTS) LTD., 53 Victoria Street, London, S.W.1.

SITUATION VACANT. Reinforced concrete designer-draughtsman required. Familiar with frame structures and general design to Code of Practice. Good prospects, five-days' week, luncheon vouchers, and pension scheme. Apply, stating experience and salary required, to JOHNSON'S REINFORCED CONCRETE ENGINEERING CO. LTD., Artillery House, Artillery Row, London, S.W.1.

SITUATION VACANT. Junior structural engineering assistant, A.P.T.I. (£343 5s. to £625 2s. plus £65 Westminster Weighting, plus London Weighting £30 at 26 years and over, £80 at 21-25). To assist in detailing of frame structures in reinforced concrete and structural steelwork, and preparation of steel schedules. Commencing salary according to ability and experience. Established and pensionable, subject to prescribed conditions. Five-days' 38 hours' week. Application forms, stamped addressed foolscap envelope from County Architect, 1 Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1, returnable by December 20. (Quote U.119 CCE). Canvassing disqualifies.

(Continued on next page.)

MISCELLANEOUS ADVERTISEMENTS.

(Continued from previous page.)

COUNTY COUNCIL OF
THE WEST RIDING OF
YORKSHIRETO CONSTRUCTIONAL ENGINEERS
AND
REINFORCED CONCRETE CONTRACTORS.

CONSTRUCTIONAL ENGINEERS AND REINFORCED CONCRETE CONTRACTORS desirous of tendering for the provision and fixing of structural steelwork and reinforced concrete in building works for the County Council should make application for their names to be included on the County Council's LISTS OF SELECTED CONTRACTORS.

Contractors whose names are already upon the County Council's lists of selected contractors need not renew their application.

Projects are classified into the under-mentioned categories, and applicants for inclusion on the lists should state the category or categories of work for which they wish to be considered.

- (a) Works of a value between £1,500 and £5,000
- (b) Works of a value between £5,000 and £10,000
- (c) Works of a value exceeding £10,000.

All applications should give particulars of works of a similar nature which have been carried out by the applicant, together with the names and addresses of three Architects or Engineers to whom reference can be made, and the name and address of the applicant's Banker.

Applications to be sent in writing to the Deputy County Architect, Bishopgarth, Westfield Road, Wakefield, not later than 10.0 a.m. on January 19, 1957.

BERNARD KENYON

Clerk of the County Council

County Hall, Wakefield.



Gunitite & Cementation

Systematic repairs to structures based on
systematic diagnosis of defects

WHITLEY MORAN

& CO., LTD

SPECIALISTS IN THE REPAIR OF
ENGINEERING STRUCTURES

5, Old Hall Street · Liverpool 3

Telephone: CENtral 7975

GEORGE WIMPEY & CO. LIMITED

have vacancies for

REINFORCED CONCRETE
DETAILERS

Interesting work on a wide variety of projects, with opportunities for advancement for experienced men. It is regretted that Trainees cannot be considered at this stage.

Five-days' week, 9.0 to 5.30, Staff Restaurant.

Applications to:

W. F. C. CROSER, M.Sc., M.I.C.E.
27 Hammersmith Grove, London, W.6.

SITUATION VACANT. Engineer. Recent graduate in civil or mechanical engineering or practical engineer with plant experience required by rapidly-expanding international company. Initial appointment in London area. Interesting and varied work, and good opportunities. Apply to READY MIXED CONCRETE, LTD., 19 Dartmouth Street, London, S.W.1.

SITUATIONS WANTED.

SITUATION WANTED. Reinforced concrete engineer, with 22 years' design and site experience, requires a responsible position with consulting engineers or contractors. Box 4401, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

PART-TIME WORK. Detailing draughtsman, with seven years' experience, is ready to undertake work in evenings and at week-ends for consulting engineers. Any structure. Neat and accurate. Good lettering. Box 4402, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

PATENT

PATENTS. The Proprietors of British Patents Nos. 647,972 for "Improvements in Ceramic Constructional Units, and in Reinforced Beams and Floors Constructed Therefrom", 647,975 for "Improvements in the Construction of Floors by Means of Terra Cotta or like Blocks", and 663,910 for "Improvements in Hollow Moulded Blocks for Constructional Purposes", desire to enter into negotiations with a firm or firms for the sale of the patents or for the grant of licences thereunder. Further particulars may be obtained from MARKS & CLERK, 57 and 58 Lincoln's Inn Fields, London, W.C.2.

FOR SALE

FOR SALE. Steel plates and sections to size. Also tubes up to 10 in. N/B. E. STEPHENS & SON LTD., Bath Street, London, E.C.4, Clerkenwell 1731.

FOR HIRE.

FOR HIRE. Lattice steel erection masts (light and heavy), 30 ft. to 150 ft. high, for immediate hire. BELLMAN'S, 21 Hobart House, Grosvenor Place, London, S.W.1.



M-W.791

TENTOR on top!

Tentor Bars have been proved the most efficient and economical medium for concrete reinforcement. Their acceptance by reinforced concrete engineers has been ready and widespread.

The Tentor bar owes this success to two main factors—lower costs and a first class delivery service. It is very economical because of high standards of tensile and bond strength, effecting a saving of up to 15% of the cost of Plain Rounds. It is backed by a delivery service programmed to meet contract requirements, supplying bars cut to length or bent to schedule.

*Reinforced concrete framed winding engine house at Hem Heath Colliery.
Architect: W. A. Woodland Esq.,
F.R.I.B.A., Divisional Chief
Architect, West Midlands
Division, National Coal
Board.*

*Reinforced concrete engineers: Matthew &
Munby Limited.
Contractors: R.
John Addison
& Sons Ltd.*

Complete technical information is freely available on request

THE

TENTOR BAR

CO. LTD.

43 Upper Grosvenor Street, London, W.1.

Telephone: GRO 8111

Tentor is manufactured by

GUEST KEEN & NETTLEFOLDS (SOUTH WALES) LIMITED CARDIFF • McCALL & CO. (SHEFFIELD)
LIMITED TEMPLEBOROUGH SHEFFIELD • THE UNITED STEEL COMPANIES SHEFFIELD

GLASGOW

NEWCASTLE

LEEDS

MANCHESTER

LEICESTER

BIRMINGHAM

LONDON

BRISTOL

CARDIFF

STAFFORD

DUBLIN

LIVERPOOL

BRC

*Specialists in Reinforced Concrete Design
and Suppliers of Reinforcement, with
Design and Branch Offices strategically
placed throughout the British Isles*

**REINFORCED CONCRETE IS
CONSTRUCTION AT ITS BEST**

There
are vacancies
for experienced
engineers in several
of our design offices.

The British Reinforced Concrete Engineering Co. Ltd., Stafford

M-12781